Rethinking Energy; Navigating Change
10 Global Insights

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Energy Market Authority

This book is published to commemorate the
10th edition of the Singapore International Energy Week (SIEW),
23 – 27 October 2017.

Published by Energy Market Authority of Singapore
991G Alexandra Road, #01-29, Singapore 119975
www.ema.gov.sg

ISBN 9789 8111 44424

“ We are, I believe, reaching the limits of what this planet can hold. We have to accept that we are all passengers on this one planet and if we don’t reduce this consumption of carbon energy, we are in serious trouble. ”

Mr Lee Kuan Yew

Minister Mentor, Singapore
Singapore International Energy Week 2008

“ In Singapore, we are preparing ourselves for a new energy future. The uncertainties are major and there are three questions which we ask ourselves: Will future energy prices rise significantly? What will be the global regime on climate change? And what new technologies will emerge? ”

Mr Lee Hsien Loong

Prime Minister, Singapore
Singapore International Energy Week 2010

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Mr Ng Wai Choong
Chief Executive
Energy Market Authority of Singapore

The theme of the 10th edition of SIEW, "Rethinking Energy; Navigating Change," prompts us to consider the impact of renewables integration, energy storage demands, changing regulations and grid digitalisation.

When Minister Mentor Lee Kuan Yew spoke at the first Singapore International Energy Week (SIEW) in 2008, the world was vastly different. Oil prices were on the rise. Shale gas was not yet commercially viable. Coal was the fastest growing fossil fuel for the fifth consecutive year. Renewables were in the early stages of adoption and electric vehicles were a rarity.

Since then, the global energy landscape has changed drastically. Volatile oil prices have only recently recovered from the downturn. The uptake of solar and wind energy has greatly increased due to lower prices and better performance. Energy efficiency has become a priority post the Paris Agreement.

Today's global uncertainty requires us to rethink our energy policies and strategies. The theme of the 10th edition of SIEW, "Rethinking Energy; Navigating Change," prompts us to consider the impact of renewables integration, energy storage demands, changing regulations and grid digitalisation.

It is clear that as we look to the future, energy players will need to stay nimble and well plugged into developments. SIEW was conceived to help the industry do so by fostering conversations on emerging energy trends and issues. That is also the objective for this book.

Rethinking Energy; Navigating Change: 10 Global Insights brings together 10 leading energy minds from across the world to share their views on our collective energy future. Each thought leader contributed a chapter that examines our greatest energy challenges, opportunities and strategies for navigating our ever-evolving energy landscape.

The result is a diverse set of perspectives from international organisations, think tanks and industries regarding our energy future. They explore pertinent issues that will affect the transformation of the global energy landscape. More importantly, they offer strategies to succeed in this uncertain landscape.

I hope you enjoy reading *Rethinking Energy; Navigating Change: 10 Global Insights*. On behalf of the Energy Market Authority of Singapore and the SIEW network, I thank you for your ongoing efforts in helping to strengthen the global energy conversation. ■

Mr S Iswaran
Minister for Trade and Industry (Industry)
Singapore

The Singapore International Energy Week (SIEW) has reached an important milestone this year with its 10th edition. The conference themes of the past decade reflect the evolution and significant changes in the global energy sector, such as the development of shale gas and innovations in renewable technologies. However, what remains immutable is the importance of energy security, economic competitiveness and environmental sustainability to support growth. It is therefore critical for policy makers and industry players to be nimble, well-informed and effective in their response to dynamic shifts in the energy landscape.

These attributes take on added significance for Singapore, a relatively small economy with no natural resources. We have taken various steps to diversify our energy sources and strengthen the competitiveness of our energy sector. We have built a liquefied natural gas (LNG) terminal to gain access to competitively-priced natural gas from around the world and facilitate LNG-related ancillary businesses. We have also progressively liberalised our electricity market – in the second half of 2018, all consumers will be able to choose the electricity retailer and package that best meets their needs.

On sustainability, Singapore is committed under the Paris Agreement to reduce our emissions intensity by 36 per cent from the levels in 2005 by the year 2030. We are also supporting the deployment of more solar power, and investing in technology and innovations to address our energy challenges and sustainable development objectives. For instance, we are catalysing research and development efforts in energy storage, solar forecasting and energy management systems to better integrate renewables. In line with Singapore's Smart Nation initiatives, we are also harnessing advances in information technologies and digitisation to further enhance our energy system through a smart grid.

It is also important for us to remain plugged into the global discourse on energy, and to work closely with partners around the world. In 2018, Singapore will assume the Chair for ASEAN energy discussions and will strive for greater energy collaboration within the region and with our Dialogue Partners. SIEW, a premier global energy event that fosters visioning, dialogue and the sharing of best practices with industry and other stakeholders, will remain a key platform to bolster energy cooperation.

This book, *Rethinking Energy; Navigating Change: 10 Global Insights*, reflects the spirit of cooperation and forward thinking that SIEW represents. It showcases diverse perspectives from key energy players, reinforcing the need for closer collaboration between nations, government agencies, industry, as well as international organisations. I hope that you will gain valuable insights from this publication on how we can work together as a global community to meet our growing energy demands sustainably while realising our economic potential and social aspirations. ■

It is therefore critical for policy makers and industry players to be nimble, well-informed and effective in their response to dynamic shifts in the energy landscape.

Looking back and looking ahead: Energy development in Southeast Asia

Dr Fatih Birol
Executive Director
International Energy Agency

...it is a good time to not only look back at how far the region has come, but also to look forward to the opportunities and challenges the region is likely to face in the future.

The energy world looked very different when I began my career 30 years ago. One of the biggest changes has come from Southeast Asia, which back then was only beginning to emerge on the global energy scene. As we celebrate the 10th edition of the Singapore International Energy Week and the 50th anniversary of ASEAN (Association of Southeast Asian Nations), it is a good time to not only look back at how far the region has come, but also to look forward to the opportunities and challenges the region is likely to face in the future.

The changes I have seen in Southeast Asia over the course of my career have been profound. For example, electrification was scarce in many parts of the region when I was a student. Yet by the time I joined the International Energy Agency (IEA) in the mid-90s, electrification was expanding rapidly and becoming a force for economic growth. The percentage of people with access to electricity in Lao People's Democratic Republic (Lao PDR) was just 12 per cent in 1994, but over the following 20 years, that figure has flipped on its head – now only about 12 per cent of people in Lao PDR lack access to electricity.

Economic growth has been similarly staggering in the region. In 1994, Gross Domestic Product (GDP) in Singapore, for example, was just under US$100 billion. Two decades later its GDP has almost tripled in size. Vietnam's economic growth has been equally impressive, growing from around US$40 billion in 1994, to close to US$150 billion today, more than a threefold per capita increase. Other countries in the region have shown similar economic success.

Growth in the energy sector has also been remarkable. For example, Malaysia has more than doubled its production of natural gas, while Indonesia went from producing insignificant amounts of coal to being one of the world's largest coal exporters. Meanwhile the region as a whole has increased power generation from hydropower by almost 400 per cent since 1994.

These last few decades have been defined by such rapid growth – and there is more growth yet to come. This is a region on the rise and almost every country has a remarkable energy story.

Singapore is a major trading hub for oil and oil products and is well on its way to becoming the same for liquefied natural gas (LNG). The Philippines is the world's second largest producer of geothermal power. Thailand is a leader in energy efficiency with its Integrated Energy Blueprint. Vietnam is a remarkable success story in terms of access to energy, increasing rural electrification to almost 98 per cent. Indonesia is a globally important producer of coal, oil and natural gas. Lao PDR is a major exporter of electricity, having tripled its power exports since 2000. Malaysia is having success encouraging the expansion of renewable power through feed-in-tariffs and other policy measures. Brunei Darussalam is a major exporter of oil and natural gas, and Myanmar and Cambodia have the resources available to become significant producers and exporters of hydropower in the coming decades.

The region's challenges are significant, and they will require smart policy, technological innovation, market reforms and timely investment.

These are stories of success and potential. But success comes with a price – energy demand is set to increase dramatically. It is demand for electricity specifically that will shape the energy outlook for the region over the coming decades. In all, some 400 gigawatts of generation capacity are set to be built by 2040 – roughly equal to the combined installed capacity of Japan and Korea today – of which a significant amount will be coal-fired. In fact, Southeast Asia is one of the only regions in the world that will see a rise in its share of coal for power generation.

This is understandable: coal is relatively inexpensive and abundant. But it highlights the need to significantly accelerate the deployment of more efficient technologies to cut down on not only CO_2 emissions, but also air pollution. Many countries in the region are asking us now if it is possible to balance the priorities of access to energy, economic growth, emissions reductions and clean air.

My response is: yes, it is possible. But it won't always be easy.

It starts with cooperation, something that Southeast Asia has decades of experience with. Projects like the ASEAN Power Grid and the Trans-ASEAN Gas Pipeline can help accelerate the development of more remote or high-cost energy resources while enhancing energy security. Bringing together the region's energy markets and grids could be a key factor in ensuring balanced and equitable economic growth for all countries in the region.

It will also require investment. In fact, securing the region's energy needs could require US$2.5 trillion of cumulative investment over the coming 25 years, more than half of which would be for the power sector. A further US$420 billion would be needed for energy efficiency. It is policy makers who will play a critical role in setting the conditions to attract and mobilise this investment.

The region's challenges are significant, and they will require smart policy, technological innovation, market reforms and timely investment. With the right efforts, Southeast Asia can continue the momentum of the past 25 years to build on its position as one of three growth centres in Asia.

It has been fascinating to follow Southeast Asia's rise in the global energy sector throughout my career. When I first joined the IEA as a junior analyst, I could not have imagined that one day as Executive Director, I would have the honour of inviting not only China and India into the IEA family as Association members, but also three ASEAN member countries: Indonesia, Singapore and Thailand.

This expansion of the IEA family to Asia has been a milestone for the IEA, representing a shift to emerging countries that are increasingly shaping the world's energy dynamics. It also defines a historic few years for global energy governance as the world engages in the greatest energy transition since the Industrial Revolution. I look forward to continuing this journey with Southeast Asia as these countries stake out their positions as strong, sustainable, responsible and innovative energy leaders. ■

Winning from disruption: Can Singapore become a test-bed for new energy solutions?

Mr Neil McGregor
Group President and CEO
Sembcorp Industries

A wave of disruption sweeping over the global markets due to rapid advancements in technology is creating two major imperatives for governments: improving the living standards of their populations while also ensuring sustainable economic growth.

Interconnectedness, the hallmark of the information age, is fostering consumers who are increasingly aware of the world around them and who demand constant advancements in their way of life.

Historically, the principal agent of change in the energy markets has been supply – the quest to secure our growing needs while diversifying fuel resources.

Today, demand and consumer experience are the major catalysts. An unprecedented pace of transformation is shaking up our world, ranging from making renewable power generation mainstream, to putting electric and autonomous vehicles on our roads, to redrawing the flow of goods and services in a “sharing economy”.

It is impossible to pick long-term winners from the variety of new energy solutions being tested and implemented. It does appear, however, that our future will be shaped by three key influences: growing digitalisation, more consumer-centric commerce and higher environmental consciousness.

New emission reduction targets are promoting greater energy efficiency. The world’s average energy intensity, or the energy consumed per unit of Gross Domestic Product, fell by nearly a third between 1990 and 2015, according to the United States (US) Energy Information Administration. This trend is well entrenched.

However, growing digitalisation could boost our electricity consumption exponentially. Demand will also grow as we provide coverage to the swathes of population in sub-Saharan Africa and parts of Asia that still lack electricity. Mass adoption of electric vehicles could become another major new source of power demand.

Electricity is expected to account for nearly 40 per cent of the world’s incremental energy demand to 2040, versus a 25 per cent share of the increase over the past 25 years, the International Energy Agency forecast in its World Energy Outlook 2016.

Meanwhile, as coal use declines in a decarbonising world, solar and wind power are emerging as the alternatives of choice, helped by a rapid drop in production costs.

Several signatories to the Paris Agreement of December 2015 have set mandatory renewable energy targets, with the Asian economic giants China and India leading the charge.

Gas: the perfect complement to renewables

Renewables, however, suffer from intermittency, and power storage has not yet arrived as an economically viable wholesale solution. Natural gas is an excellent complement to renewables as a sustainable alternative fuel, providing grid stability and supply security.

Major new conventional gas discoveries in recent years, along with the shale gas boom in the US, have made this low-carbon fuel abundantly available. At the same time, we have been adding to the world’s liquefaction capacity to provide mobility to increasing volumes of natural gas, connecting supply to distant markets.

An unprecedented pace of transformation is shaking up our world, ranging from making renewable power generation mainstream, to putting electric and autonomous vehicles on our roads, to redrawing the flow of goods and services in a “sharing economy”.

The modes of liquefied natural gas (LNG) production, trade and delivery are also adapting to the unique needs of the new wave of smaller and distributed gas demand centres, especially in developing Asia. The focus has turned to Floating Liquefied Natural Gas and Floating Storage Regasification Unit systems as lower-cost solutions with a shorter time to market.

Can Singapore build on its pivotal role as Asia’s long-established oil trading and price-discovery hub to serve the emerging needs of the gas and power markets?

The country’s maiden LNG import and regasification terminal on Jurong island, operational since 2013, has already been expanded to a capacity of five million metric tonnes per annum (mtpa), which is planned to be further raised to 11 million mtpa. The country is building spare capacity for LNG storage and re-loading in order to serve fast-growing markets in the region.

In April 2017, Singapore launched its first LNG truck-loading facility, capable of supplying gas to domestic industrial consumers as well as for use as bunker fuel to ships calling on its ports.

Singapore, recognised for its probity, security and surety, is well-placed to serve as a digital hub in the new energy order...

Hub of connectivity for gas and power

The major issues in gas and power today are last-mile connectivity and development of new markets.

Indonesia, for example, lacks a grid connecting their hundreds of inhabited islands. As result, many of them end up with the costlier option of burning diesel to produce their own electricity.

How do we give these islands access to gas as well as power? It needs an industrial solution, as well as funding, both of which are available in Singapore. China, India, Bangladesh, Thailand, Vietnam, Cambodia and Myanmar are among markets with major development opportunities.

Sembcorp, Singapore's first commercial importer and retailer of natural gas, is actively engaged in financing and executing gas-fired, and other super-efficient thermal, as well as renewable energy projects in the region. In the process, it is also implementing technologies that leap-frog plant efficiency and emission reduction.

India, which aims to double its wind power capacity and boost its solar power capabilities by almost five-fold by 2022 under its COP21 commitments, is a perfect fit for Sembcorp's drive to provide green energy solutions. The company has close to 1,200 megawatts (MW) of wind and solar power projects in operation and under development in the southern, western and central regions of India.

Myanmar is a significant exporter of natural gas, but less than a third of its population has access to power supply. Sembcorp's 225 MW Myingyan power project, which is being developed under a 22-year build-operate-transfer contract, will be one of Myanmar's largest gas-fired plants and will help alleviate some of the supply shortfall.

Back home, Sembcorp Marine is pioneering "Gravifloat", a near-shore modular floating facility for LNG and liquefied petroleum gas (LPG), which can be developed into a liquefaction as well as a receiving terminal suitable for supplying to small and mid-sized power plants.

Meanwhile, the inevitable diffusion of digital technology along the energy supply chain and the growing interlinkages between markets make information security an important issue for policy makers and companies alike.

Singapore, recognised for its probity, security and surety, is well-placed to serve as a digital hub in the new energy order – a place for suppliers and distributors to house their data reliably and conduct trade in a free and open market that also assures a high velocity of cash.

A perfect place to incubate

Singapore's small area and dense urban environment also make it ideal for test-bedding new energy technologies. In recent years, it has piloted photovoltaic systems, hydrogen cars, autonomous vehicles and electric vehicles, to name a few.

Energy supply is also being increasingly integrated into urban solutions. By test-bedding smart homes and smart cities, Singapore creates a tactile experience for governments and businesses to see what is possible with new technology.

A new challenge for the city-state is to find a way to trickle down the benefits of innovation to its smaller enterprises, the traditional brick-and-mortar businesses and jobs that are under threat from the digital era.

Some countries, struggling to manage the transition from an industrial to a knowledge economy, are choosing to erect trade barriers in a bid to protect their workers. Singapore remains committed to continued liberalisation of trade and investment, and is ensuring that its education system and career training programmes support skills that deliver higher value as technology and artificial intelligence take over more routine tasks.

There is a lesson worth drawing from the winning strategy in ice hockey: you skate to where the puck is going to be. Applying that to the world of energy and commerce, you need to be able to identify the winning evolutionary trends and invest in them well ahead of time.

The stakes are higher today than ever before because disruption occurs faster than evolution.

Singapore, with its dynamic workforce and culture of risk-taking and innovation, is well-placed to ride the digital wave in commodities trading and incubate new energy technologies. ■

The future of energy – a sustainable, reliable and affordable energy supply

Mr Joe Kaeser
President and CEO
Siemens AG

It was a moment that will probably be remembered centuries from now, a moment when reason and unity prevailed in a time marked by rampant populism and rising political polarisation, a moment that reverberated around the world. For the first time ever, almost all nations signed a binding global climate agreement. Each country committed to meeting nationally determined targets. The goal of the agreement was to prevent global warming from exceeding two degrees Celsius above pre-industrial levels.

From today's perspective, it's high time to do that. By 2040, the world population is likely to grow from 7.5 billion today to almost 10 billion and global demand for electrical power is expected to rise 78 per cent. How can the world's soaring demand for energy be met and CO_2 emissions be reduced at the same time? How can we make sure the supply of energy is sustainable, reliable and affordable in the future?

To make the world's energy supply sustainable AND do so in an economically feasible way, a prudent and practical long-term plan is needed. Failure is not an option, because there is no Plan B for the planet.

And the entire global community must be involved to make it work. On an operational level, it will require a complete redesign of the entire energy value chain – from the exploration of resources, power generation, transmission and distribution, to the conversion and consumption of energy. The transition in the long-term to a decarbonised economy starts with the broad-based deployment of renewable sources of energy and further innovation. Renewables provide abundant, clean and increasingly cheaper electricity, and that encourages further electrification. The world is making good progress in this area. In 2015, for the first time ever, we installed more renewable than conventional power generation capacity. Today, renewable energy (excluding hydropower) accounts for 14 per cent of global power generation capacity. We expect this figure to rise to 32 per cent by 2040.

Siemens is not only shaping the redesign of the energy value chain; it was also the first major industrial company to commit to cutting its CO_2 emissions by half by 2020 and to making its ecosystem carbon neutral by 2030.

Efficiency is part of the sustainability story

Today, energy is wasted in every sector and industry. Buildings account for about 40 per cent of the energy used worldwide. So, the potential to boost energy efficiency here is huge. Siemens' building technologies have already reduced energy demand by 30 per cent in 100 Singapore commercial buildings. We are very proud of the fact that the technologies of our Environmental Portfolio have enabled customers all over the world to reduce CO_2 emissions by 521 million metric tonnes. That is around twice Singapore's annual CO_2 output.

To make the world's energy supply sustainable AND do so in an economically feasible way, a prudent and practical long-term plan is needed. Failure is not an option, because there is no Plan B for the planet.

Energy supply must be reliable and secure

That's why the broad deployment of renewable energy alone is not enough. Until significant advances are made in large-scale energy storage, conventional power generation will be needed to compensate for the fluctuating feed-in of renewables. Here, we will see a shift to decentralised, flexible, low-carbon gas-fired power plants. In general, energy systems as a whole will have to become more flexible to integrate the broader range of technologies. In addition to that, more efforts must be made to protect the energy system against cyber threats.

Fortunately, progress is being made in the area of energy storage. For instance, renewable power lends itself well to electrolysis, a process that can be used to produce hydrogen and other fuels like alcohols, with waste gases delivering the carbon. This is a promising technology because it draws carbon out of the atmosphere and converts it into energy that can be stored for future use.

Energy supply must be affordable

This means that any energy transition must make sense both ecologically and economically at every stage. In 2016, the International Renewable Energy Agency announced that the cost of the electricity generated by photovoltaic systems and wind turbines had fallen by about 80 per cent since 2009 and could decrease by as much as an additional 60 per cent between then and 2025. At favourable locations, we now see that the power generation costs of renewables can already compete with those of conventional power generation solutions.

But much more can be done in this area. Digital technologies can be used to improve

From the perspective of a global technology company like Siemens, transforming the global energy landscape means electrifying, automating and digitalising the world!

product design and to optimise processes, services and infrastructure. They can be used to collect and analyse data from individual elements of the energy system in order to boost their operational performance as well as that of the system as a whole. It's already evident that digitalisation has the potential to bring operating costs down by several orders of magnitude. That will help us keep energy affordable.

What will the future of energy look like?

Humans have been inventing ways to utilise electricity since the late 19th century. Why? Because no form of energy is more versatile than electricity. It's easy to convert. It's as fast as light, weighs nothing, and can therefore quickly be transported over long distances. And once generated, it is clean. Yet today, more than 130 years after the invention of the first electrical generators, large parts of the economy still rely on fossil fuels. We burn them to power road and rail vehicles, ships and aircrafts, to heat homes and buildings, to carry out industrial processes — and, yes — to generate electricity. These activities alone account for roughly two-thirds of global greenhouse gas emissions. On top of that, too many regions of the world are not electrified yet. More than one billion people do not have access to electricity. Clearly, decarbonisation and demand for energy will boost electrification efforts.

Today, practically every industry uses automation technologies to accelerate processes and make them more efficient and accurate. They are vital to meeting energy efficiency targets. It makes sense to automate.

The digital revolution we are currently experiencing demonstrates how fast things can change. Technologies that did not even exist as ideas just a few years ago are a reality today. A similar development is likely in the energy sector. The "Internet of Things" could well be followed by an "Internet of Energy" – a decentralised, decarbonised and intelligent energy system. Digitalisation connects the entire energy system and vastly expands its capabilities.

Electrify, automate and digitalise the world

From the perspective of a global technology company like Siemens, transforming the global energy landscape means electrifying, automating and digitalising the world! That is how we envision the future of energy.

So, technology is not the bottleneck. But the transition to a decarbonised economy can only succeed if the government does its part by creating the right regulatory environment. And that requires leadership that goes beyond the 140 characters of a social media message.

Perhaps the most effective action would be to more stringently attach a price to carbon. Carbon pricing based on market mechanisms, emission standards, and intensified energy sector research and development would be a powerful incentive to electrify as quickly as possible. It would also make investment in energy-efficient technologies even more worthwhile than it already is today.

Germany's energy transition can serve as a case study because it shows what worked well and what didn't work at all. Today, one-third of the electricity consumed in Germany is already generated by wind and solar, yet the reliability of its energy system is one of the highest in the world.

Or take Singapore. Its government had the foresight to prepare the country's energy system for the future. With its highly efficient gas-fired power plants, Singapore can easily integrate renewable energy and ensure reliability of supply in the future.

Siemens is supporting Singapore on its way to becoming a Smart Nation. Earlier this year, we opened our 'Digitalization Hub' in Singapore. More than 300 scientists and software developers there will work on developing digital technologies that will improve the quality of life for its citizens and help create a leading urban ecosystem.

Can we succeed in making the long-term vision of a decarbonised global economy real? I say, yes!

As global government and business leaders, we must take this transformation into our hands and make it a success.

First and foremost, this is about our responsibility to our children and future generations. And second, there is no other option, no Plan B, for our planet. So, there is work to be done – and we better start now. ■

Ushering in a new era of electrification and embracing the future of sustainable energy development

Dr Shu Yinbiao
Chairman
State Grid Corporation of China

The global transition to clean, low-carbon, intelligent and efficient energy is accelerating, and this once again has inaugurated the rapid growth of electrification, i.e., re-electrification.

When Thomas Edison lit the first electric light bulb in 1879, human society entered the era of electricity. In the following century, many countries' power industries began to take shape, which rapidly advanced the electrification process and became an important driving force for economic growth.

The electrification of each country often slowed once reaching a certain level, due to the constraints of energy production and consumption structure. For example, when power consumption accounted for about 20 per cent of a country's energy end-consumption, its electrification would enter a period of slower growth. This was especially evident in major developed countries.

However, in the 21st century, a new energy revolution is booming as a result of climate change, energy security and other factors. The global transition to clean, low-carbon, intelligent and efficient energy is accelerating, and this once again has inaugurated the rapid growth of electrification, i.e., re-electrification. With re-electrification, this round of the global energy transition has several distinct characteristics that differentiate it from the electrification process of the last century.

From the perspective of energy production, this round of electrification is green, i.e., there is massive development and utilisation of clean energy. Unlike the traditional way – in which power was generated mainly from coal, natural gas and other fossil fuels – this will replace fossil energy with clean energy. With the rapid development of wind and solar power, the global renewable energy generation took up about 28 per cent of the total energy mix in 2016, an eight per cent increase from 2005; and this figure in China was 25 per cent, which increased nine per cent from 2005. In the future, the growing economic efficiency of renewable energy generation will enhance the replacement of fossil energy by renewable energy. It is expected that the installed capacity of renewable energy will contribute more than half of the global total energy mix by 2030.

As for energy consumption, this round of electrification is extensive, i.e., the scope and intensity of energy utilisation will be greatly increased. Driven by technological progress, electricity replacement for coal and oil has witnessed a larger scale and a wider range of use in the civil, industrial, commercial, construction, transportation and other fields. And any energy that can provide power and heating may be replaced with electricity. Transportation is a key area for electricity replacement. By the end of 2016, global electric vehicle (EV) ownership exceeded two million, about 50 per cent of which was in China. It is estimated that by 2030, EVs will make up more than 50 per cent of cars sold worldwide. Electricity has become a common alternative for a variety of energy demands, and in many countries, electric cooking, heating and warming have gained increasing popularity.

This is a round of intelligent electrification across the entire energy system, i.e., the level of intelligence of the energy system is upgraded. With the rise in large-scale integration of renewable energy and diversified customer demands, higher requirements have been placed on the stability and flexibility of the power system operation.

The development of information technology and artificial intelligence – including the Internet, big data, cloud computing – and their deep integration with energy technology, has supported and contributed to the construction of more secure and intelligent energy systems. In the future, there will be significantly elevated levels of intelligence in energy production, transmission, allocation and utilisation, among other things. This will greatly reinforce the system of self-healing performance and customer friendliness, which will in turn help make the flexible integration of varied power sources, plug-and-play devices and interactive services, a reality.

As a platform for power transmission and allocation, power grids play a key role in energy

To adapt to energy reform, there is an urgent need to speed up the upgrading of power grids, and to build energy interconnection with strong grids, extensive interconnections, high intelligence and open interactivity.

transition and re-electrification. To adapt to the energy reform, there is an urgent need to speed up the upgrading of power grids, and to build energy interconnection with strong grids, extensive interconnections, high intelligence and open interactivity. According to the International Energy Agency's forecast, the investment demand of global grid construction will reach US$7 trillion in the next two decades.

Centred on renewable energy, China will speed up the construction of a safe, economic, efficient and sustainable new energy system.

It is estimated that by 2020, China's non-fossil energy will take up 15 per cent of the total primary energy, non-fossil energy will take up 35 per cent of the total installation and electricity consumption will take up 25 per cent of the total energy end-use. And by 2030, these figures will reach 20 per cent, 53 per cent and 30 per cent, respectively.

State Grid Corporation of China therefore bears the mission of providing clean energy and promoting energy transition. In recent years, through technological innovation and capital investments, we accelerated the construction and upgrading of power grids, as well as contributed to the transition and development of China's energy sector.

Firstly, by developing the Ultra High Voltage (UHV) power transmission, we facilitated the development of large-scale renewable power bases in West China, and enabled power transmission to power centres in East and Central China which were 1,000-3,000 km away. China has since become the only country that commercially operates the UHV transmission technology. There are currently 21 UHV projects currently under operation or construction, with the total length of transmission line reaching 30,000 km.

State Grid is also the leader in large-scale integrated renewable energy, with integrated hydro, wind and solar photovoltaic (PV) power reaching 220 gigawatts (GW), 130 GW and 700 GW respectively. This has contributed to the annual growth rate of installed wind and solar power reaching 46 per cent and 62 per cent, respectively – higher than the world average of 24 per cent and 41 per cent.

Secondly, we implemented electricity replacement projects which focused on replacing coal and oil with electricity. We completed 41,000 projects and replaced a total of 103,000 gigawatt hours (GWh) of power with electricity in 2016, and aim to further this to 580,000 GWh by 2020. The major ways of electricity replacement include developing electrified transportation, electric heating and replacing oil with electricity in harbours, airports and pumping wells.

Thirdly, we enhanced the smart grid and strengthened technical upgrades with the construction of the China-Singapore Eco-city in Tianjin and the National Wind-PV-Storage-Transmission Demonstration Project in Hebei Province. The flexible transmission technology has also been put under research and application. More than 430 million smart meters were installed and the largest EV fast-charging network on highways was constructed which covered 121 cities in 16 provinces. To implement our "Internet & EV charging facilities" strategy, we constructed the Smart Internet of EVs Platform that integrated multiple functions such as EV charging services, resource monitoring and information sharing, connected 165,000 EV charging poles and served one million EVs.

From 17-23 June 2017, State Grid successfully conducted a clean power supply test in Qinghai Province for seven consecutive days, with the maximum load of 7.36 GW and a 100 per cent power supply of solar, wind and hydropower. This has proved the efficiency of measures to accommodate renewable energy, which underscored our determination to promote the renewable energy transition in China.

Given factors such as resource endowment, technology development and energy policy, the pace of energy transition and the process of re-electrification vary among different countries. In the long run, it is our inevitable choice to advance the clean and low-carbon energy transition and smart, extensive and green electrification, for energy sustainable development. ■

Delivering our energy future

Mr Thomas Kuhn
President
Edison Electric Institute

Around the world, the electric power industry is leading a profound transformation. In the United States (US), electric companies are developing and deploying smarter energy infrastructure, transitioning to even cleaner generation sources, and creating the innovative energy solutions customers want. As we look forward to the energy landscape in 2030, these principles will continue to guide us and provide us with opportunities to collaborate and make progress on key policy priorities.

At its core, our vision for the future of energy is customer-driven. With every advancement in technology, customers are using electricity in more ways than ever. Society's ever-increasing dependence on electricity underscores the vital importance of the electric power industry for security and prosperity, and it also reinforces the role that electric companies play in improving the lives of all.

The electric power industry is the most capital-intensive industry in the US. As a whole, the industry contributes US$880 billion to the US Gross Domestic Product and invests more than US$100 billion each year. This level of investment is more than twice what it was a decade ago.

Our industry also supports more than seven million American jobs — a critical component of delivering our energy future. This includes nearly 2.7 million jobs directly provided through electric power industry employees, contractors and supply chain, and investments and an additional 4.4 million induced jobs.

That is one in 20 jobs in America. Each job directly provided by the industry supports an additional 1.7 jobs throughout US communities. Not only are we supporting the current workforce, we are always looking for opportunities to jump-start the next generation.

Key to delivering our energy future is building smarter energy infrastructure. The industry already is building a smarter, more dynamic, cleaner, more resilient and more secure energy grid.

US investor-owned electric companies invested US$32 billion in the distribution system and $20 billion in the transmission system in 2016. To date, the industry has installed more than 70 million digital smart meters in 55 per cent of all US households and we project that number will grow to 90 million by 2020.

This is one building block of a smarter, stronger energy grid. Investments that hasten the integration of new technologies — such as small-scale renewables, energy storage and microgrids in our homes and businesses — are another.

Protecting the energy grid is our top priority and every day we are working to improve grid security, reliability and resiliency. Our security strategies constantly evolve and are closely coordinated with the federal government through a partnership called the Electricity Subsector Coordinating Council (ESCC). By working together through the ESCC, industry and government greatly enhance our nation's ability to defend and protect against cyber and physical security threats. Maintaining and strengthening this critical partnership will continue to be a priority well into the future.

In addition to smarter energy infrastructure, our vision for the future of energy reflects the opportunities we see in increasingly clean energy

At its core, our vision for the future of energy is customer-driven. With every advancement in technology, customers are using electricity in more ways than ever.

In the end, we envision electric companies providing all sorts of distributed energy resources and technologies — including private solar, microgrids, storage and also energy efficiency and demand response — that are integrated harmoniously across the energy grid.

sources. In just 10 years, the mix of resources used to generate electricity has changed significantly.

Today, more than one-third of the US energy mix comes from zero-emissions resources, including nuclear and renewable energy. As a result, the industry's CO_2 emissions were nearly 25 per cent below 2005 levels in 2016 — the lowest annual CO_2 emissions level since 1988.

The use of renewable energy to generate electricity is projected to almost quadruple between 2010 and 2040 and electric companies are already the largest investors in renewable energy in the US. Virtually all of the wind, geothermal and hydropower in the country – and 64 per cent of installed solar capacity – is provided by electric companies. In addition to renewables, we also are leading the way on energy storage – our industry uses more than 90 per cent of all storage.

Electric companies have always relied on a variety of domestic energy resources to generate electricity. As our energy mix changes, maintaining a diverse, balanced energy mix remains a top industry priority. This is the best way to preserve the safe, reliable and affordable electricity that our customers expect – because energy that isn't affordable, isn't sustainable.

As the electric power industry does its part to deliver our energy future, we also must empower customers with innovative energy solutions. As an industry, we are changing the way we provide services to customers and individualising those services – for the large customers (like data centres and major corporations) that want to use renewable energy; for the residential customers who want to manage their energy use using connected devices and through web-based platforms; and for the major cities that want to be more sustainable and reduce their carbon footprint.

New technologies and innovations in the movement toward smart communities are helping to drive efficiencies, improve sustainability, spur economic development and enhance quality of life. Many of these "smart" projects are in complete alignment with our industry's core skill set of applying data, technology and scale to deliver reliable and affordable electricity to a variety of customers.

The growing smart community trend creates new opportunities for collaboration among electric companies, cities, universities, technology companies, other business partners and citizens because the energy grid is a key platform for smart communities. While each community may have different reasons for wanting to be smart, all smart communities share common attributes — and they are all powered by smart connections and by smarter energy infrastructure.

As cities and communities seek smart and sustainable mobility solutions, electric transportation is a critical component. According to a study by the Electric Power Research Institute, the widespread adoption of electric vehicles could reduce greenhouse gas emissions by 550 million metric tonnes annually in 2050, equivalent to removing 100 million passenger cars from the road. Our members are investing US$250 million in customer programmes and projects to deploy charging infrastructure and to accelerate electric transportation. Beyond personal cars, transportation electrification is taking hold in public transit, commercial delivery vehicles and ride-sharing applications.

All of these trends are well underway today. In the end, we envision electric companies providing all sorts of distributed energy resources and technologies — including private solar, microgrids, storage and also energy efficiency and demand response — that are integrated harmoniously across the energy grid.

For more than two decades, the Edison Electric Institute (EEI) has had the opportunity to both learn from and share knowledge with our colleagues at Asian electric companies about critical issues and evolving trends in our industry. Important examples of this knowledge exchange include EEI's Asian Energy Financial and Investment Conference, held during the Singapore International Energy Week, and the casebook, *Financing Asia's Electricity Sector 2035: Making it Happen*, published by EEI in 2016.

As we look to 2030, we will continue our work with EEI's international members to achieve our shared goal of delivering reliable, affordable and increasingly clean energy to customers — and delivering our energy future. ■

The challenges of energy-poor Japan

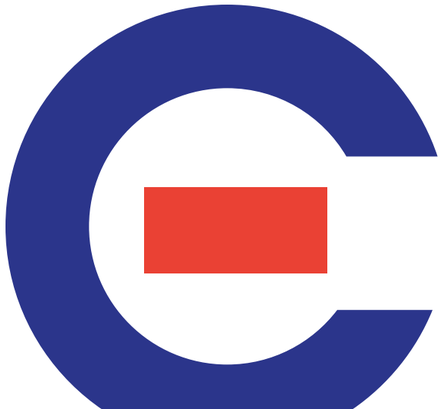
Professor Masakazu Toyoda
Chairman and CEO
The Institute of Energy Economics, Japan

Japan is one of the world's most energy-poor countries, with domestically-produced energy accounting for only five to six per cent of its primary energy supply. It is also the third largest economic power in the world. A secure energy supply – domestic or not – is indispensable for sustained economic growth, and Japan has undoubtedly been working continuously towards this.

In the past half century, Japan has faced three major crises that have hindered the country's efforts in ensuring its energy security.

The first was two oil crises in the 1970s, when oil prices shot up nearly 20-fold.

The second was the 1997 agreement on the Kyoto Protocol. Describing the successful agreement as a crisis may sound strange. However, Japan was bound by the CO_2 emission reduction agreement that virtually only Europe and Japan accepted, making it difficult for Japan to maintain its international competitiveness. The protocol imposed an additional constraint on Japan. On the other hand, there was greater scope to reduce emissions in the European Union after energy-inefficient Eastern Europe had been integrated into Europe in the early 1990s.



The third crisis was the 2011 nuclear power plant accident, which does not require more explanation.

Following these crises, it has not been easy for Japan to rebuild its energy and environmental policies and secure a stable energy supply. This is because the three crises necessitated contradictory policies. Let me explain further.

The first crisis, namely the sharp rise in oil prices, necessitated that Japan, at least temporarily, restrict energy consumption and reduce its dependence on oil from the Middle East. As a result, the country promoted energy conservation, viewed nuclear power plants as a quasi-domestic energy source and diversified fossil fuel supplies to cut its dependence on oil. "Energy security" and "economic efficiency" became the biggest policy targets.

While already featuring one of the world's highest energy efficiency levels, Japan has set the aforementioned ambitious target of improving the energy intensity just after the oil crises. Is this target achievable?

The second crisis with regard to the Kyoto Protocol required fossil fuels to be replaced with as much renewable and nuclear energy as possible. In this time, solar, wind and geothermal energy sources failed to expand as much as expected. Solar and wind power generation costs remained high. Geothermal energy development was heavily opposed by spa-loving Japanese. As such, "environmental friendliness" and "economic efficiency" were given priority.

Nuclear energy use in particular made steady progress. While non-hydro renewable energy's share of Japan's power mix rose from less than 0.1 per cent in the early 1970s to only three per cent in 2010, the share of nuclear energy increased from two per cent to 25 per cent of total power generation. Of the 2030 target power mix drafted in 2010, renewable energy accounted for 20 per cent and nuclear energy for 50 per cent. Nuclear energy was seen as a champion energy source from the viewpoint of the so-called three Es: "Energy security", "Economic efficiency" and "Environmental friendliness".

The third crisis led the public to doubt the safety of nuclear energy as Japan's champion energy source. Japanese views around nuclear energy remained divided and inconsistent. Public opinion polls indicated that the majority called for reducing nuclear energy use, while others sought to eliminate nuclear energy altogether. When asked whether they supported or opposed nuclear energy, nearly 60 per cent said they opposed it.

Following the Fukushima incident, a government advisory panel, which I was on, took four years to draft a new energy mix. The new target energy mix has adopted energy conservation as a top priority – a 35 per cent improvement in energy intensity over the next 20 years, close to the level after the oil crises.

The new mix also takes a portfolio approach from the viewpoint that no energy source can be perfect on its own when it comes to the three Es ("Energy security", "Economic efficiency" and "Environmental friendliness") plus S (Safety). Therefore “diversification and balance” have become our keywords.

In particular, the energy mix seeks to secure “safety” and sets three targets – (1) raising Japan’s energy self-sufficiency rate to about 25 per cent — equal to the level before the nuclear plant accident from the viewpoint of “Energy security”; (2) keeping electricity rates at not more than the present (2015) levels from the viewpoint of “Economic efficiency”; and (3) setting the CO_2 emission reduction target at a level comparable to European and US levels from the viewpoint of “Environmental friendliness”.

As a result, renewable energy, nuclear energy, gas and coal are each positioned to account for roughly a quarter of the power mix, while oil is to be used primarily for transportation and industrial purposes. Of the primary energy supply mix, however, oil still captures the largest share at close to 30 per cent.

Japan’s present energy and environmental policies face at least five challenges in working towards the target energy mix.

The first challenge is the further promotion of energy conservation. While already featuring one of the world’s highest energy efficiency levels, Japan has set the aforementioned ambitious target of improving the energy intensity just after the oil crises. Is this target achievable?

Energy conservation has an inherent limit, while renewable power generation features low capacity utilisation rates.

The second is nuclear energy. Citizens’ confidence in nuclear safety has not sufficiently recovered. One and a half years after the accident, a nuclear regulator independent of the administrative agencies was created. The regulator set safety standards at one of the world’s toughest levels – particularly from an anti-earthquake standpoint. As a result, additional construction work and screening at nuclear power plants have taken more time than expected. Of the 54 nuclear reactors in operation before the accident, only 42 units (excluding those subject to decommissioning) are viewed as technically operational at present. However, six years after the accident (as of June 2017), only five have been restarted. Thorough and stringent but efficient inspection is a challenge.

The third is the accelerated expansion of renewable energy. As a result of the feed-in tariff (FIT) system for power utilities to purchase all electricity generated with renewable energy, the approval of renewable energy power generation projects has been swift. In the past three years, approved renewable power generation capacity exceeded 85 gigawatts. Associated problems include rapid hikes in electricity rates under high FITs, implemented projects limited to only about one-third of approved capacity, renewable power generation projects’ concentration in solar photovoltaic, and limited progress in wind and geothermal power generation. The FIT system has been revised to solve these problems.

The fourth challenge lies in attaining a greenhouse gas emission reduction target as a result of the aforementioned measures. Due to the delay in the restart of nuclear plants, progress has not been smooth. Energy conservation has an inherent limit, while renewable power generation features low capacity utilisation rates. Energy conservation and renewable energy expansion alone are not enough to make up for the delay.

The fifth challenge is in establishing a transparent and fluid Asian liquefied natural gas (LNG) market. Asian LNG importers, particularly those of Japan – which are the biggest importers, were affected by the Asian premium between 2011 and 2014 when oil price sky-rocketed. At that time, Asian LNG prices were frequently six times higher than that of Henry Hub in the United States. This was because LNG prices in Asia had been oil indexed while the Henry Hub price reflected the balance between demand and supply, although this balance was substantially relaxed in both markets.

The important measure is to form a market which can send a sound price signal to Asia, for example, by building Asian hubs, by eliminating destination clauses which prevent resale and eventually by expanding the spot market in Asia.

It is important for Japan, China and Singapore, which are the front runners in this regard, to cooperate with one another towards the same goal.

Japan would be happy to see its efforts and difficulties in the energy field as a useful reference for other energy-poor countries as they draft their own energy and environmental policies. ■

Building a better energy future: The role of gas

Mr Peter Coleman
Managing Director and CEO
Woodside

Over the decade that Singapore has hosted its International Energy Week, we have seen structural shifts in global energy markets occurring at the same time as the world's population and energy consumption have continued to rise.

For liquefied natural gas (LNG) producers, it has been a formative decade that presented opportunities, but also challenges, forcing us to reconsider our strategies and to develop new markets and uses for our product.

As an industry, we responded to the rising demand for energy by undertaking significant investment in new production capacity. This new production was coming online when we were tested by the dual challenges of the downturn in the oil price and the remarkable growth in the shale industry in the United States (US).

The availability of gas globally has introduced a new volatility in pricing, but the good news is this increased affordability is fuelling further growth in demand. Developments in technology have also played a role in enabling market expansion, as Floating Storage Regasification Units have become more accessible – opening up LNG imports to new countries.

We have an opportunity now to turn these countries into long-term customers. Our challenge is to convince them that gas is the fuel of choice, not only because it is available and affordable, but also because of its low emissions profile and ability to offer both stable baseload power generation and dispatchable power.

The structural shifts in the global gas market are timely, coinciding with international attempts to reduce emissions and develop energy sources that are both clean and reliable.

The role gas plays is poised to grow, both in its own right as a provider of baseload power and in partnership with renewables, ensuring system stability and reliability.

Gas meets both of these criteria and obviously needs to be part of the solution as the world looks to reduce emissions at a time of growing global energy consumption.

Looking to the future of energy in 2030, it is clear that both gas and renewables will be making a much bigger contribution to world energy than they are today. The role gas plays is poised to grow, both in its own right as a provider of baseload power and in partnership with renewables, ensuring system stability and reliability. In the years ahead, we also expect to see renewables offer alternative power sources for our plants, reducing our emissions, and increasing the volume of gas that we can sell rather than deploy for our own power generation.

Energy storage solutions may also change our operations. Battery technology still has to overcome limitations before it can store and deliver large-scale energy, but bespoke applications are already viable. At Woodside, we are developing world-leading technology for the industrial use of a lithium-ion battery energy storage system on an offshore oil and gas facility.

And there will, no doubt, be other breakthroughs that will transform the global energy mix, as hydrogen emerges as an energy source and the take-up of electric cars becomes more widespread.

Within our own industry, too, there will be change. One only needs to consider the rapid shifts of recent years to realise how quickly this can occur. The rise of shale gas in the US has been a game-changer, but this market and its pricing are still evolving while other sources of supply will also be needed. Major gas producers in other regions are demonstrating, through commitments to increase production, that they anticipate strong demand and intend to be there to meet it.

It is no surprise that Asia is the fastest-growing LNG market globally, as populations and governments in the region understand that industrial and economic development must co-exist with a commitment to improve air quality.

To continue delivering the gas that will be required, we as producers have had to adapt not only our operations, in response to lower-cost competition, but also the way in which we appeal to potential customers.

We have had to become more sophisticated and flexible in contracting and marketing as we deal with new customers who have different expectations with regard to the length of contracts, the conditions attached to them and the pricing point. The LNG market is rapidly becoming more liquid and will develop further in the years ahead as we move towards a transparent on-the-water price.

It is encouraging that new countries are switching to gas for power generation and industrial uses, but as producers, we also need to explore opportunities for new uses.

Indeed, we are already building a new market for gas as a transport fuel in ships and on land. Historically, LNG has had a very small footprint in transport, but that's changing.

We are seeing the emergence of a market for LNG as a marine fuel ahead of the enforcement from 2020 of the International Maritime Organisation's new limits on sulphur emissions.

We cannot say yet for sure how big that market will be, but we do know that, as a shipping fuel, LNG is much cleaner than heavy fuel oil and diesel. We do know the potential market in the global shipping industry is equivalent to the total LNG supply in the world today. Even a 10 to 20 per cent market penetration is going to fundamentally shift industry dynamics. And we do know there are ports and harbours in the world, including Singapore, that are already taking it into their own hands to ensure emissions are reduced and air quality is improved by increased LNG use.

There are also encouraging signs of an uptake of gas for land-based transport, with countries including India exploring opportunities for gas-fuelled buses. In Australia, Woodside is working with major miners and equipment manufacturers on LNG fuelling of locomotives and mine-haul trucks, and collaborating with the shipping industry to develop a "Green Corridor" for LNG-fuelled marine trade to Asian markets.

It is no surprise that Asia is the fastest-growing LNG market globally, as populations and governments in the region understand that industrial and economic development must co-exist with a commitment to improve air quality.

Singapore has been central to many of the recent market developments. As a busy trading port, Singapore is readying itself for the anticipated demand for LNG bunkering. Not only is gas crucial to the nation's own energy security, but it has also recognised how vital gas will be to the whole region and moved to deal itself into that equation by vying to attract increased LNG trading activity. Although Singapore is not itself a producer of gas, its fortunes are closely aligned with our industry.

Anyone who tried to read the tea leaves a decade ago, when the Singapore International Energy Week was launched, would have struggled to predict the structural shifts that have occurred in the intervening years.

Forecasting market trends is always perilous. Nevertheless, one can confidently assert that global energy consumption will continue to rise as populations grow. If we, as gas producers, can pursue the opportunities that this presents and navigate our way through the challenges, then we will have a big and growing role to play in building a better energy future. ■

The role of renewables in the transformation of Europe's energy landscape and the outlook ahead

Mr Steve O'Neil
CEO
REC Group

Today, renewables in Europe already have lower generation costs than new coal or gas power plants.

As a European brand of solar panels which began 20 years ago in Norway, REC Group is proud to be involved in shaping Europe's future energy market. We foresee it as being green, flexible and affordable – leading by example for other regions around the globe. Solar energy will greatly contribute to this, thanks to its evolution so far and its future potential.

Europe – the driving force behind renewables, and solar in particular

Today's common silicon solar cell dates back to 1954, and in the 1960s, solar photovoltaic (PV) was exclusively used as an energy source in space engineering due to its prohibitive costs. However, triggered by the oil crises in 1973 and 1979, as well as the risks associated with nuclear power, research in solar PV production was intensified to produce better and more affordable solar cells.

Nonetheless, the leap into the mass market only occurred during the 1990s. It was driven by Europe, Germany in particular, by preferring renewable energy sources and defining incentives for the use of these technologies. This made Europe a pioneer and trend-setter in the evolution of renewable energies into a suitable large-scale energy source.

Founded in 1996, REC Group has also conducted pioneering work which included the first hand-washed wafers and cell efficiency that was as low as a few per cent. Today, we are the first company to produce solar panels with innovative half-cut cells on an industrial scale. These deliver up to 20 per cent cell efficiency at competitive prices.

Solar PV has also evolved from its humble beginnings into a multi-billion-dollar industry. At the end of 2016, a cumulative total of more than 300 gigawatts (GW) of solar PV was installed worldwide – a 4,500 per cent growth over just 10 years. Forecasts expect the global cumulative total of solar PV installations to reach 700 GW by 2020.

For years, Europe has proven to be a highly stable market for solar that will sustainably continue to grow across all countries in the future.

During the past 40 years, each time solar PV capacity doubled, costs dropped by approximately 30 per cent. This makes solar PV as competitive as conventional electricity sources in many regions worldwide. This development is expected to continue as Bloomberg New Energy Finance (BNEF) expects costs for solar PV to drop another 66 per cent by 2040. There are many indicators that show solar PV is becoming increasingly attractive for a wide range of applications.

Even if China, India and the United States (US) surpass Europe as the leading solar regions in terms of newly-built solar capacity, the European market will continue to be a driving force and a source of innovation.

Being the fourth largest producer of emissions, Europe is highly aware of its responsibility in the fight against climate change and has renewed its commitment to the Paris Climate Agreement. Today, renewables in Europe already have lower generation costs than new coal or gas power plants. We can therefore expect Europe's power structure to primarily rely on renewable energies by 2040, with the share of coal-based energy dropping by 80 to 90 per cent, according to BNEF. Together with wind power, solar will be the dominant basic energy source in Europe.

Urbanisation – the cities are the key

For the first time in history, more than half of the world's population today lives in urban centres – and this is rising. Europe is a "potpourri" of growing metropolitan areas with a growing hunger for energy. Air quality must also not deteriorate and the limited available space should be used efficiently.

Approximately one-third of energy demand will be needed to power buildings. Therefore, future residential and urban construction will require modern environmental technologies for producing renewable energies.

With its Directive for Buildings, the European Union has defined a binding framework for its members, stating that all buildings constructed from 2021 will have to be designed as nearly-zero-energy buildings. These requirements can only be achieved by integrating solar PV solutions into the buildings e.g., facades, and not just installed on rooftops.

Solar PV will also be made an energy source as part of general infrastructure, including roads. We believe this trend, triggered by innovative projects, will radiate globally from Europe into other developed markets.

Digitalisation should also empower greater use of real-time data in order to better balance and optimise power production and consumption.

Other drivers for Europe's green energy transformation

The complexity of the European energy market encourages innovation. The growing share of decentralised, renewable and fluctuating energy production presents new challenges for grid management, pushing Europe to find solutions for a smart integration of renewable energies into the grid and mitigating generation peaks.

Firstly, the prices of storage technology — in particular, lithium-ion batteries — are plummeting just like they have for solar PV. BNEF expects prices to drop by 73 per cent as early as 2030, allowing batteries to be used to mitigate peak loads and feed-in peaks for grids and plants. Europe is also a key driver in the research for new, more efficient, or even alternative storage technologies.

Secondly, electric mobility. While electric vehicles (EVs) will increase total power consumption, they will help to keep the grid stable because they make it more flexible. The growing fleet of EVs (the New Energy Outlook study by BNEF expects 13 per cent in Europe and 12 per cent in the US by 2040) will act as a huge connected power storage whose batteries will preferably be charged when there is a power surplus, and that can be used as a peak load reserve when the vehicles are stationary.

Thirdly, digitalisation. For energy management, it will allow more flexible and less vulnerable infrastructures, such as the so-called smart grids or virtual power plants at local, national and international levels. The international energy trade is a key element of the energy market in Europe. Digitalisation should also empower greater use of real-time data in order to better balance and optimise power production and consumption.

The digital network will also help to manage the transformation from the classic producer-consumer market towards a connected prosumer market. That is because the market for rooftop solar PV systems, both residential and commercial, will account for a huge share of Europe's energy sector. This will create new local-level trade forms at key touchpoints (neighbourhood or peer-to-peer trading), which would be impossible to implement without digitalisation.

Outlook for Europe's solar industry

The rise in solar PV for self-consumption across residential and commercial applications demonstrates the competitiveness of solar energy across European countries. It is a model that the EU will continue to push and set an important precedent for other regions.

More research and development in core solar technology, as well as digitalisation and smart integration, will produce new solutions, such as blockchain technology (peer-to-peer trading). This will support Europe's energy transition.

With our operational headquarters situated in Singapore, REC Group is best equipped to contribute to the energy transition. Singapore, with its strategic location, expertise in semiconductors and remarkable commitment to sustainability and renewable energies, has the potential to become a "think tank hub" for the integration of solar PV into the electricity mix.

In 2016, the solar market in Asian countries was 65 per cent of the 80 GW global market. By 2020, we expect this region to represent 60 per cent of the 112 GW worldwide. India is expected to become a top-three global market, growing from a little over 5 GW in 2016 to 15 GW in 2020. Southeast Asia is expected to triple in market size by 2020 from 3.5 GW in 2016. This demonstrates Asia's stronger growth rates of renewable capacities, and being able to look to Europe's development of solar PV and its experiences, will be an advantage for the region.

The Paris Climate Agreement was a strong testament to the global understanding that climate change is real and it is up to us – the human race – to change it now that there is a way out.

Today, it is clear that solar energy is becoming the standard clean and affordable energy source.

It is an unstoppable movement. Governments, communities, businesses and private households are making an effort. All of us in the solar industry can be proud to be part of this exciting energy transition in Europe, in Asia, and on a global scale. ■

Technological disruptions are creating markets in clean energy

Mr Philippe Le Houérou
Executive Vice President and CEO
International Finance Corporation

Over the past several years, the energy sector has undergone disruptive technological advances that have driven down the cost of renewables, especially solar, to well below many other sources of power.

It is just the beginning of these promising trends, which have been, and will continue to be at the heart of discussions by government leaders, regulators and energy professionals at the annual Singapore International Energy Week.

Consider these major developments for renewables: (a) Solar panels now cost half the price of what they did in 2010 and could fall by another 60 per cent in the next decade; (b) New off-grid small solar home systems are providing African households with basic electricity for lower than US$7 a month; (c) Photovoltaic (PV) and wind energy are now cheaper than thermal energy in many markets; and (d) Battery storage technology is gaining momentum to provide cheaper capacity – with battery cell prices falling rapidly toward the threshold of about US$200 per kilowatt hour (kWh), a level below which solar plus batteries becomes competitive in many applications, and eventually providing baseload.

Battery storage technology could be a game-changer. It could soon be possible to offer round-the-clock electricity by storing wind and solar power. Reduced battery costs will also boost the affordability of electric vehicles on roads, which could set in motion a new and virtuous cycle of managing supply and demand on regional power grids – with electric vehicles acting as a source of power, while also charging from the grid.

Disruptions are also taking place in various markets. Many countries are embracing competitive auctions, which are yielding record low tariffs. Mexico achieved the lowest prices in Latin America during last September's auction that resulted in a winning bid of US 3 cents per kWh, while Zambia registered a price of US 6 cents per kWh, with the support of International Finance Corporation's (IFC) Scaling Solar programme. In these cases, innovative regulators have supported competitive renewable generation.

The good news is these evolving technologies and business models have the potential to help close the big gap in energy access for more than one billion people globally, including nearly half a billion people in Asia. The better news is this gap can be closed in a clean manner, helping to curb carbon emissions.

It's true that the complexity of the task is daunting. Globally, hundreds of billions of dollars in new investments are needed annually for universal access to affordable, sustainable and modern energy. With official development aid at US$142.6 billion last year – and flows to the poorest countries dropping – we know that the financing gap can be filled only by leveraging more private sector investment.

Asian countries are extremely well placed to capitalise on these crucial shifts and opportunities. The region already is playing a lead role in the transition to cleaner power. In India, for instance,

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Expanding and modernising the grid is key to boosting renewable energy penetration. In fact, the greatest investment in energy efficiency can come from reduction in transmission and distribution losses.

the 750 megawatts single-site Rewa Solar Project proved to be a game-changer, showing that even in markets where solar has strong traction, innovative new models can achieve greater cost efficiency and deepen the ecosystem of developers and suppliers.

With 20 international and national players offering bids for the Rewa Project, the lowest tariff bid came in at just US 4.4 cents per kWh for the first year, without subsidy. Other promising developments include Chinese solar PV manufacturer's Chint New Energy Development providing technical expertise in Turkey, Pakistan and Bangladesh, and IFC's investment in India's first PV independent power producer, Azure Power.

During this global energy transition, natural gas will play an important role, offering a low-carbon alternative to other fossil fuel-based power generation.

Liquefied natural gas-to-power also offers new opportunities for countries facing declining gas reserves such as Bangladesh and Myanmar. Singapore's leadership in transition fuel has supported Bangladesh in its efforts to raise risk capital in international markets. In addition, Singapore-based strategic partners are building a regional presence and expanding into other markets.

Problems persist in the power sector due to inefficiencies in distribution. Expanding and modernising the grid is key to boosting renewable energy penetration. In fact, the greatest investment in energy efficiency can come from reduction in transmission and distribution losses.

Lastly, the utilities of the future will likely take advantage of smart metering technology and commercialisation to improve billing and efficiency. They will integrate storage solutions to conquer stability issues and take advantage of renewable opportunities. The "Internet of Things" is the glue that will orchestrate and help optimise the new model grid. Asia's first-rate telecommunications infrastructure, especially cellular data, is a key prerequisite.

At IFC, we are working with the private sector and client countries to help them adapt to the rapidly changing power sector. The short- and medium-term focus of our new power sector strategy will be to continue shaping markets in grid-tied renewables, promoting more gas-to-power projects, and helping scale-up and commercialise the revolution in distributed generation. Over the longer term, we want to help countries create sustainable energy markets that can be scaled up and replicated, and take advantage of the upcoming disruptions in the energy sector.

Globally, IFC has decades of experience in financing, structuring and leading complex energy infrastructure deals in emerging markets, with more than 40 gigawatts of power generation financed to date and an extensive record supporting renewable energy and natural gas development. Mobilising capital from other international investors – banks, sovereign funds and international financial institutions – is a key element of our strategy.

This strategy enables us to achieve greater development impact than we could on our own, and for our co-investors, our involvement also provides a more attractive balance of risk and return.

More importantly, IFC offers solutions beyond financing, including assisting governments through our public-private partnership advisory, and by sharing new insights and examples from our experience that leverage innovation and create markets.

Taken together, these efforts will help spur the evolution of the energy sector. By combining innovative financial tools with disruptive technologies, there is great potential power to scale up renewable energy sources and to give us a chance to fight climate change at a scale equal to the challenge. ■

Three steps for the world to tackle climate change

Mr Ben van Beurden
CEO
Shell

Change is constant and I believe it must be embraced. The energy transition as the world moves to a low-carbon future means change on a global scale, and it must be embraced too.

A successful transition would transform the world's energy system and preserve the health of the planet. It would help avoid the most serious effects of climate change, boost air quality and improve the lives of billions by providing greater access to energy.

It is a cause well worth working for.

While none of us can foresee exactly how the transition will happen, there are three important trends.

Firstly, the world's population will grow. There are currently more than seven billion people and the United Nations (UN) expects there to be 11 billion by 2100.

Secondly, all those people will seek to improve their living standards. That could mean a first car or a first lightbulb, and all of it will involve the consumption of energy.

More people, enjoying a better life, is something to look forward to. And these two factors make it likely the transition will take place while the energy system doubles in size.

This leads to the third founding fact: the world is going to have to work out how to meet the increase in demand while tackling greenhouse gas emissions.

There are other factors at play too.

We can expect the growth of cities to accelerate. More than half the planet's population already live in cities. By 2050, the proportion will be around two thirds, according to the UN, with over half of the world's urban population concentrated in Asia.

The global population growth will not be uniform. The UN predicts 750 million more people in Asia by 2050. By the end of this century, 3.2 billion of the 3.6 billion extra people we can expect on this planet will be in Africa. The vast majority of them will be in sub-Saharan Africa.

This energy transition is a truly global phenomenon made up of many transitions, all moving at different speeds in different places and sectors. What happens in Singapore is important, but what happens in Ethiopia is at least as important. From Denmark to the Democratic Republic of the Congo, from New Zealand to Nigeria, to China, to India… there is a lot of work to do.

A successful transition would transform the world's energy system and preserve the health of the planet. It would help avoid the most serious effects of climate change, boost air quality and improve the lives of billions by providing greater access to energy.

Powerful drivers like these offer huge opportunities, and they are also what make the energy transition a real challenge.

Yet, with enough social willpower, collaboration and the right policies, it is within the world's grasp to succeed.

There is currently a lot of wind and solar being added to the world's energy system and that must accelerate.

But even if the whole power sector went zero-carbon tomorrow, that would only decarbonise some 20 per cent of energy needs. Fossil fuels would still provide much of the other 80 per cent.

For the world to decarbonise, there are three areas it must focus on: the energy it uses, the energy it produces and cleaning up emissions. It is essential that the world advances in all three areas at the same time, with every element of society playing its role.

Looking at the energy we use first: this planet needs a societal shift away from high carbon intensity, yet everything people do needs energy. Part of the answer is to put a cost on the emissions related to that consumption, through government-led carbon pricing mechanisms. These have the effect, over time, of pulling both industry and consumers towards low-carbon products.

But that is not a miracle cure. People are not, for example, going to abandon their homes because they become more expensive to cool. People need extra help. This means two things need to happen in steps: on one side, regulation and standards for industry and companies;

Removing carbon from the supply of electricity, alongside a switch of consumption, is a first step to decarbonising society.

on the other, support such as price incentives for consumers.

As renewables, combined with lower-carbon natural gas, help the power sector to reduce emissions, the world must also make a massive shift towards consuming energy as electricity through innovations like electric cars.

How electricity is produced is just as important. There is little point shifting to electricity if that electricity is produced by burning coal. Removing carbon from the supply of electricity, alongside a switch of consumption, is a first step to decarbonising society.

Issues like intermittency and storage mean the world is still some way off from meeting its electricity needs with renewables. These can be mitigated by a transition to natural gas, which produces around half the carbon dioxide of coal when burnt for power.

Yet even with the right policies, the right societal backing and enough collaboration, infrastructure does not change overnight. There are some areas of the economy that will not be able to achieve zero-carbon. The industrial sector emits as much carbon dioxide as the power sector and it cannot simply switch to electricity for all its processes. The basic chemical processes of steel and cement manufacturing, for example, mean they will inevitably produce carbon dioxide. The weight and capacity limits of batteries mean there is no immediate zero-carbon solution for air travel, for shipping or for heavy freight. There is no “off button” for emissions.

Dealing with the emissions that remain will rely, at least in part, on carbon capture and storage. More than that, the world needs “net negative emissions”. This can be achieved by using plants to take carbon dioxide from the atmosphere and then burning it for power – the carbon dioxide created can then be kept from the atmosphere using carbon capture and storage.

If the world can address demand, fix supply and deal with what remains, it has every chance of achieving the successful energy transition it needs.

The oil and gas industry should play its part and I am determined Shell will do so wherever it makes commercial sense.

As a major energy user, the industry must tackle the carbon dioxide intensity of its operations. On the supply side, it has many opportunities: in wind and solar energy, biofuels, hydrogen and digital innovation. It also has expertise in the field of carbon capture and storage. But perhaps the biggest contribution the industry can make today is by helping the shift to lower-carbon natural gas. Burning gas can also contribute to cleaner air as it produces a tenth of the particulates of coal.

Asia itself has many opportunities through the energy transition. The region’s growing, urbanising population creates the chance to build low-carbon infrastructure from the start.

The youth, energy and optimism of Asia can take it a long way.

Asia has the chance to help the world towards a sustainable, and more prosperous, energy future.

It is a future we must all hope for and work towards. ■

Dr Fatih Birol

Executive Director
International Energy Agency

Fatih Birol became Executive Director of the International Energy Agency (IEA) on 1 September 2015. Dr Birol has been named by *Forbes* as one of the most influential people in the world's energy scene. He is Chairman of the World Economic Forum's (Davos) Energy Advisory Board and serves as a member of the United Nations Secretary-General's Advisory Board on 'Sustainable Energy for All'. He is also the recipient of numerous awards from the government, industry and academia. Dr Birol was previously IEA's Chief Economist and Director of Global Energy Economics, with responsibilities that included directing the Agency's flagship World Energy Outlook publication. He is also the founder and chair of the IEA Energy Business Council, which provides a forum to enhance cooperation between the energy industry and energy policy makers.

Mr Neil McGregor

Group President and CEO
Sembcorp Industries

Neil McGregor has a unique and varied background spanning business, operations and investment in the energy and infrastructure sectors across Europe, the United States, Asia and Oceania. His international experience includes over a decade spent in Singapore serving regional markets. Previously, he led companies in India and Singapore as CEO, including Singapore LNG Corporation where he was credited with building Singapore's first LNG terminal, and PowerSeraya Group. Mr McGregor also formerly headed Temasek International's Energy and Resources Group and its Australia and New Zealand team, and was Senior Managing Director of Temasek's Enterprise Development Group.

Mr Joe Kaeser

President and CEO
Siemens AG

Joe Kaeser is President and CEO of Siemens AG, a global powerhouse in electronics and electrical engineering. He has more than 35 years of experience at Siemens, where he has held a variety of leading management positions in finance and strategy both in and outside Germany. Mr Kaeser began his career at Siemens in 1980 in the field of components and semiconductors, where he also worked in Malaysia and the United States. In 1999, he joined the Corporate Finance department. In 2001, he was appointed Chief Financial Officer of the Information and Communication Mobile Group. From 2004 to 2006, he served as Siemens' Chief Strategy Officer. Immediately prior to his appointment as CEO in August 2013, Mr Kaeser had served as Siemens' Chief Financial Officer for seven years.

Dr Shu Yinbiao

Chairman
State Grid Corporation of China

Shu Yinbiao has long been devoted to the management and research on power planning, construction, dispatching, large grid control, ultra-high voltage grid, smart grid, renewable energy development and international business. Prior to his appointment as Chairman, Dr Shu served as President of State Grid Construction Company, Executive Vice President and President of State Grid Corporation of China. He has attached great importance to corporate management and technology innovation, leading major breakthroughs in grid development, corporate performance, technical innovation, with large grid security level topping the world. As Vice President of the International Electrotechnical Commission (IEC), Dr Shu leads the Market Strategy Board to orientate emerging technologies and market trends, identify priorities in the new areas, and compile IEC development strategy and planning as well as strategic policies.

Mr Thomas Kuhn

President
Edison Electric Institute

Thomas Kuhn was President of the American Nuclear Energy Council before joining the Edison Electric Institute. He previously also headed the energy section of the investment banking firm, Alex Brown and Sons, and was White House Liaison Officer to the Secretary of the Navy. Mr Kuhn received a BA in Economics in 1968 from Yale University, served as a Naval Officer following his graduation, and completed a Masters in Business Administration in 1972 at George Washington University. He currently serves on the Boards of the United States (US) Energy Association, Alliance to Save Energy, Electric Drive Transportation Association and the American Council for Capital Formation. He is Chairman-Emeritus of the US Chamber's Committee of 100 and the American Society of Association Executives (ASAE). He is past-chairman of ASAE's Key Industry Association Committee and of the Trade Association Liaison Council.

Professor Masakazu Toyoda

Chairman and CEO
The Institute of Energy Economics, Japan

Masakazu Toyoda has served as Chairman and CEO at the Institute of Energy Economics, Japan (IEEJ) since 2010. The organisation has been ranked among the top three think tanks in the world in 2014-2016 in Energy and Resources Policy (Global Go-to Think Tank Index by University of Pennsylvania). Prior to joining IEEJ, he served at the Ministry of Economy, Trade and Industry (METI) of Japan where he held prominent positions such as Vice-Minister for International Affairs (2007-2008). Professor Toyoda writes on energy, environment and energy security, and also teaches at National Graduate Institute for Policy Studies (GRIPS) as an Adjunct Professor.

Mr Peter Coleman

Managing Director and CEO
Woodside

Peter Coleman has 33 years of experience in the global oil and gas industry, covering Asia, the Americas, Africa and Australasia. Mr Coleman has been Managing Director and CEO of Woodside since joining the company in May 2011. After graduating with a Bachelor of Engineering from Monash University in 1983, Mr Coleman began his career with ExxonMobil and stayed with the company until joining Woodside. He has a Master of Business Administration from Deakin University. Mr Coleman is also Chairman of the Australia-Korea Foundation, Chairman of the Advisory Group for Australia Africa Relations and advisor to the Asia Society.

Mr Steve O'Neil

CEO
REC Group

Steve O'Neil joined REC in March 2015. Mr O'Neil has 28 years of working experience in multi-diverse industries across different countries. His most recent position was CEO of Tyden Group, a leading provider of specialised security products, where he was based in the United States. Prior to this, he spent 20 years with TE Connectivity (formerly Tyco Electronics), one of the world's largest providers of products and solutions that connect and protect the flow of power and data. He served as Senior Vice President of the Consumer Devices business unit, where he was responsible for all aspects of sales, development and operations worldwide.

Mr Philippe Le Houérou

Executive Vice President and CEO
International Finance Corporation

Philippe Le Houérou joined International Finance Corporation (IFC) in March 2016. Prior to his arrival at IFC, Mr Le Houérou was Vice President for Policy & Partnerships at the European Bank for Reconstruction and Development. He also previously held leadership positions at the World Bank. As the World Bank's Regional Vice President for South Asia from 2013 to 2015, he designed a new regional strategy, restructured the Bank's regional portfolio, and more than doubled new lending. Earlier, he was Regional Vice President for Europe and Central Asia, where he led the Bank's effort to mitigate the impact brought about by the global economic crisis to the region. Mr Le Houérou holds an MBA from Columbia University and a Ph.D in Economics from the Institut d'Etudes Politiques de Paris.

Mr Ben van Beurden

CEO
Shell

Ben van Beurden became CEO of Royal Dutch Shell in 2014. He joined the company in 1983 having studied chemical engineering at Delft University of Technology, Netherlands. His career spans downstream and upstream activities in operational and commercial roles, including in the liquefied natural gas business. He became Vice President for Manufacturing Excellence in 2005, based in Houston, responsible for standards in operational excellence and high-performance initiatives in refining and chemicals manufacturing. He was appointed Executive Vice President for Chemicals in 2006, based in London, and also to the boards of a number of leading industry associations, including the International Council of Chemicals Associations and the European Chemical Industry Council. In 2013, he became Downstream Director and a member of the Executive Committee.

ENERGY MARKET AUTHORITY
Smart Energy, Sustainable Future

The Energy Market Authority is a statutory board under the Ministry of Trade and Industry. Our main goals are to ensure a reliable and secure energy supply, promote effective competition in the energy market and develop a dynamic energy sector in Singapore. Through our work, we seek to forge a progressive energy landscape for sustained growth. Please visit our website **www.ema.gov.sg** for more information.

SIEW 2017
SINGAPORE INTERNATIONAL ENERGY WEEK

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SIEW 2017 Theme: Rethinking Energy; Navigating Change

The global economy is set to pick up pace, but growth will remain uneven. Our energy landscape remains in transition with the change in dynamics of oil and gas demand and supply. Renewables continue to gain momentum as they become increasingly cost-competitive. Climate change commitments must be adhered to, and even exceeded, for a sustainable future. Against this backdrop, there is a need for energy players to stay nimble, navigate these challenges, and seize opportunities in this evolving energy landscape.

Acknowledgements

We would like to thank Mr S Iswaran, Minister for Trade and Industry (Industry), for his continuous support, as well as our colleagues at the Energy Market Authority and Ministry of Trade and Industry, who have contributed to this book in one way or another.

We also want to express our gratitude to other Singapore government agencies for their help during the production of this book, including the Ministry of Foreign Affairs, Economic Development Board and National Library Board.

We would like to show our appreciation to the energy thought leaders, who have contributed these insightful opinion pieces, and the organisations they represent. These organisations include: Edison Electric Institute; the Institute of Energy Economics, Japan; International Energy Agency; International Finance Corporation; REC Group; Sembcorp Industries; Shell; Siemens AG; State Grid Corporation of China; and Woodside.

Without your support, this commemorative book would not have been possible.


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