Middle East Power: Outlook 2035

www.siemens.com /middleeast

The Middle East is ripe with opportunities to boost power generation and its reliability for the benefit of the region's individual economies

Table of Contents

GI Consultancy
Gulf Intelligence

Dietmar Siersdorfer

Chief Executive Officer of Siemens Middle East and UAE

Uncertainty in today's world has become the new normal. The pace of change is phenomenal and companies, individuals and countries need to adapt or fall behind. The skills we have today may be obsolete a few years from now. The energy markets have also witnessed significant shifts in just the past two years – from oil price drops to the massive cuts in the pricing of renewables. In light of these changes, oil-rich countries in the Middle East have ramped up their economic diversification plans. At Siemens we have realized the necessity of viewing change as an opportunity, making a concerted effort to support the future energy mix whether by introducing digital technologies or creating new business models.

The Middle East is a growing region for power generation and will require additional capacity to meet its economic ambitions and the needs of its people. There is no doubt that renewable sources of energy, especially solar, will play a major part in its future power mix. Nevertheless, we believe natural gas will continue to be the dominant source of power generation through 2035. Highly-efficient gas turbines, from large to small, will cater to these requirements. A healthy energy mix of renewables and natural gas will achieve the optimal grid stability to supply uninterrupted power to the region's industries and homes. This will include energy storage solutions and gas-fired power plants with fast ramp up rates to complement the intermittent nature of renewables. New technologies in energy storage will come to the fore, develop, evolve and become more cost-competitive. Decentralized energy systems will also allow power users, especially in industry, to produce it independently and use it for their facilities, reducing transmission losses and carbon emissions.

As a company that has supplied key power infrastructure to the region for more than 160 years, Siemens continues to contribute to its energy transformation. Our role is not just that of a technology provider, but a co-creation partner that seeks to adapt innovative solutions to the needs of the region. This encompasses efficient power plants for diversified economies, reliable technologies that connect solar farms to the national grid, innovative energy storage solutions, and cyber security systems to protect vital power assets. Digitalization will also play a greater role in ensuring grid stability. As the digitalization of power systems allows for more monitoring and control, IoT operating systems such as MindSphere can help customers create value out of data, maximizing efficiencies and flexibility.

In the coming pages, we outline our vision of how we see the power generation sector evolving up to 2035. Until then, we believe our agility, innovation, and co-creation with customers will keep us at the forefront of creating value for the region and its people.

Mohamed Jameel Al Ramahi

Chief Executive Officer of Masdar

On behalf of Masdar, I would like to congratulate Siemens on the publication of this report. Its findings will be enthusiastically debated at this year's Abu Dhabi Sustainability Week.

Siemens is a global technology leader and a long-standing partner of the United Arab Emirates. Such partnership is underpinned by first-hand knowledge of the trends shaping today's global energy transformation.

As laid out in this report, the changes underway are far from linear. Fossil fuels will continue to play a major role long into the future. Integrating new power sources requires innovation, policy changes and new business models. Large-scale investment is needed, from business as well as government.

The way in which we generate and consume power is becoming more complex. Our industry is decentralizing and becoming more consumer-focused. Energy efficiency will arguably be one of the most important renewable energy technologies of the future.

As renewables increase their share of the energy mix, power is evolving into a technology business, less one based on commodities. The convergence of technologies on both the demand-side and the supply-side of the energy equation promises a paradigm shift, as opposed to incremental improvements on existing models. Today is an exciting time to be involved in energy.

There is no question that the Middle East will be at the heart of the transformation taking place. It has one of the world's youngest populations, some of its fastest growing economies, and its electricity demand is rising. An estimated 83 gigawatts of renewable energy capacity alone will be added to the region's energy mix by 2035.

With the world's population expected to reach 8.6 billion by 2030, concerted action is required if we are to bring about genuine sustainable development. The UAE has been swift to respond, becoming the first country in the Arab world to set a renewable energy target. By 2050, clean energy sources will meet half of the country's electricity demand.

Masdar established itself as a global renewable energy leader by achieving industry firsts, working to extend the UAE's energy leadership beyond oil. Through our pioneering projects, we deploy advanced, commercially viable clean technology at scale. We also pride ourselves on identifying the best regional and global partners to work with – like Siemens.

This thought-provoking report will broaden the understanding of any audience confronting the changing dynamics of the Middle East's power sector.

Executive Summary

- **The Middle East region would need to add 277 gigawatts of new capacity by 2035**
- **Gas is expected to remain the largest source for power generation in the region representing 60 percent of installed capacity through 2035**
- **The addition of renewable energy into the region's power mix will increase the need for innovative energy storage solutions**

The power market is transforming as energy independence and economic diversification play a bigger role. And the world's largest oil producing region is making the switch ushering in a new era for electricity generation.

Natural gas plays an important role for the region, providing an option to replace oil and save valuable resources for export. It will continue to maintain the majority market share despite new forms of energy being added. By adding gas-fired power plant capacity, the electricity produced by gas power plants would double from 731 terawatt hours (TWh) in 2016 to 1,499 TWh by 2035, according to IHS Markit.

Demand for power globally and regionally will be influenced by a number of factors, including the growing market for electric vehicles and the rising need for water desalination in countries where the resource is scarce.

Power demand in the region is expected to grow by 3.3 percent each year until 2035 while populations are increasing at an even faster rate. Some countries such as Kuwait, Oman, Qatar, Saudi Arabia and the UAE have a 3.5 percent population growth rate.

With this growing demand, IHS expects that the Middle East will need 277 gigawatts (GW) of additional capacity to boost installed capacity to 483 GW by 2035. There are new plans to diversify the energy mix on the horizon, reforms taking place and innovative technologies hurdling into the sector.

Economic diversification strategies coupled with climate change initiatives also point to other sources of energy, such as solar and nuclear power. The energy mix in the region will also include coal-fired power plants. The region has already embarked on its journey to add around 61 GW of new capacity from solar power in a little more than a decade,

which will require innovative energy storage solutions.

With the mix of resources used for power generation, the Internet of Things (IoT) will play an integral role in reducing costs and shoring up efficiencies.

Machines communicating with each other are driving a greater transfer of data, helping the grid manage a variety of sources and loads. This suite of technologies connects all types of devices with the ability to exchange information about their status to other systems. Companies and utilities can evaluate and act on this information, which is the reason digitalization has led to new business models.

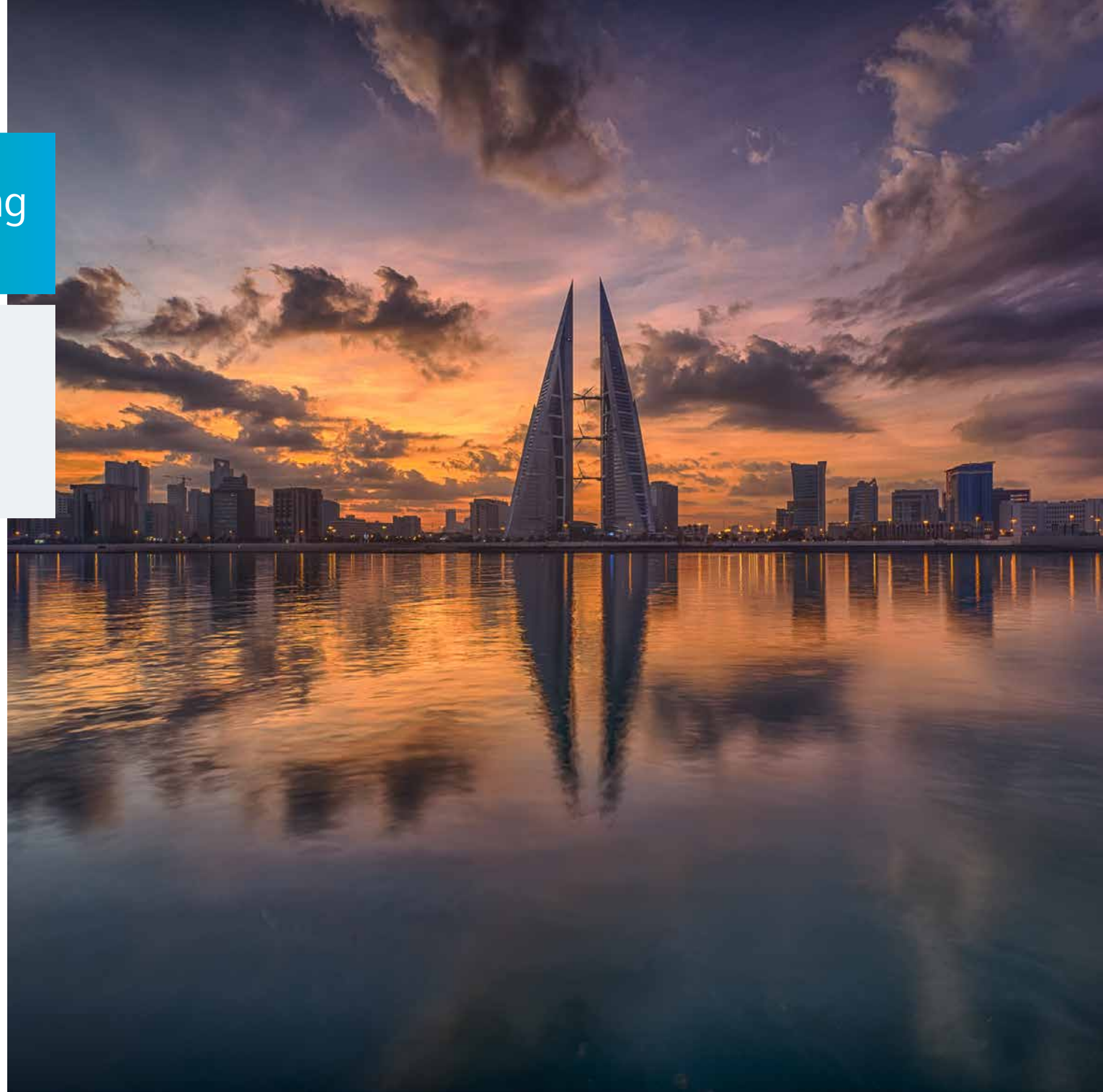
As our systems become more integrated, thanks to IoT, cyber security must also play a critical role to ensure a reliable and secure network. More than 7 percent of power utilities worldwide faced a cyber attack in 2016, according to cyber security firm Symantec. Therefore, security measures need to be increased to stop a system breach with a view that the risk has become greater in companies' operational technology than in their informational technology.

Overall, digital technologies provide a great deal of opportunity for the global power sector worth billions of dollars. The Middle East is ripe with these opportunities which not only help increase the reliability of the power sector, but also the region's individual economies.

Chapter 1

The Region's Evolving Energy Landscape

Sustained low oil prices have led to a greater push for optimization, while governments enact new energy policies



Unplanned downtime at a substation can lead to disruption in the operations of a country's key infrastructure, resulting in millions of dollars in losses to the companies involved.

Some conventional sources of power continue to reign dominant, but are losing market share as needs change.

The amount of electricity generated globally has nearly quadrupled over the past four decades. The International Energy Agency (IEA) noted in 1973 that 25 percent of the world's electricity was generated from oil. Fast forward to 2015 and that percentage has changed with oil making up just 4 percent of the total power mix.[1]

Countries began dropping oil as their main source of feedstock for power generation due to the costs associated with it, replacing it in part by natural gas. At the end of 2016, less than 1 percent of the total electricity generation was from petroleum in the United States when at its peak in 1974, oil made up 20 percent of the country's power mix.[2] Whereas Germany's use of oil for power generation has dropped 67 percent from 1960.[3]

Most oil-fired generators in countries outside of the Organization of Petroleum Exporting Countries (OPEC) are used only at times of peak electric power demand or when natural gas prices soar due to local demand. This shift to decrease the amount of oil used for power generation in most countries came during the 1970s when the world oil markets experienced sharp price increases. Economic and political events have also discouraged petroleum-fired power generating capacity additions globally.

Yet as the Middle East is flush with cheap natural resources, the region's power makeup is still almost exclusively dominated by oil and gas.[4] The region currently uses oil and natural gas to meet 97 percent of its electricity needs.

Electricity powers economies

Economic growth hinges upon connectivity and power generation. Unplanned downtime at a substation can lead to disruption in the operations of a country's key infrastructure, resulting in millions of dollars in losses to the companies involved. Outages for short periods of time can be extremely costly, highlighting the importance of power supply and reliability.

In the main oil producing region of the GCC, strong economic and social growth has increased over the decades. These countries have, as a result, increased public sector employment and spending on infrastructure, health and education. This has raised the standards of living, which has a knock-on effect to increasing demand for electricity.

Changing dynamics creating new needs

However, as the region grapples with the sustained low oil prices that have been in effect since 2014, customers are looking at ways of optimization across the board. Regulations are changing, including energy transformation policies, while business models are being revamped to become more customer focused and leverage the benefits of digitalization.

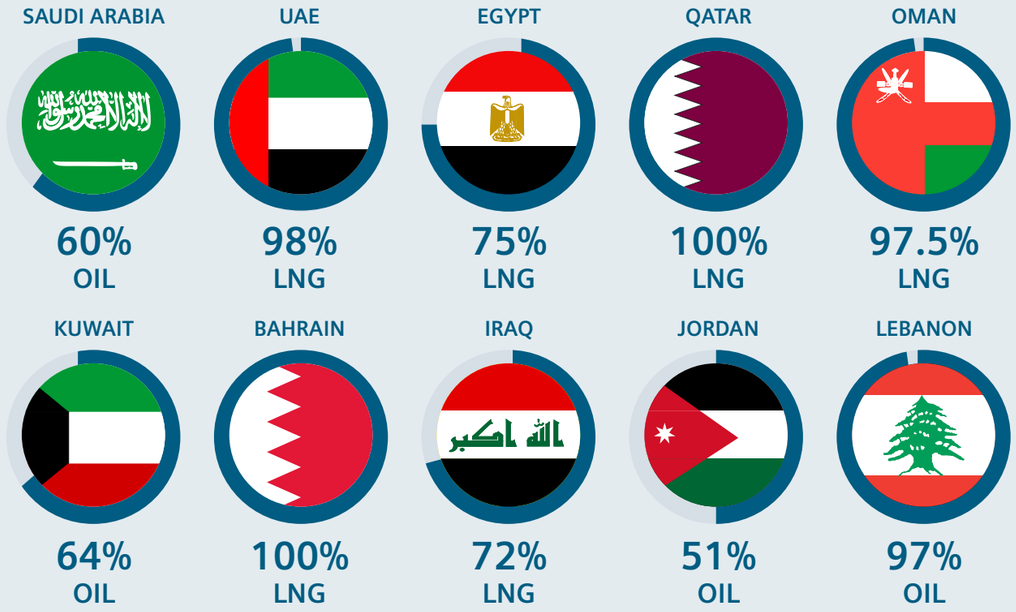
Customers are looking more for efficiency and reliability that is gained through digital technologies – which ultimately transforms the way the energy system is managed. Overall the power sector is facing its own disruption and industry players are working to provide the answers.

Industrial and commercial clients want independence with better solutions for energy control, heightened by the rise in technology and the Internet of Things.

The world over is looking at less centralized and more distributed forms of power as customers look to become more directly involved with their own generation.

This has presented a conundrum for utilities and providers, but new market players are

Main Source of Power in the Middle East



Sources: IEA and IRENA

Main Source of Power in the Middle East for 2015.

entering the sector as dynamics shift.

Saudi Arabia has set ambitious diversification plans, which also include localized manufacturing, for its energy sector.

The kingdom's domestic power consumption increased every year up to 9 percent until 2015, which has been dominated by oil. To decrease reliance on oil for power generation, Saudi Arabia is looking to replace old infrastructure that operates using oil as feedstock. The country announced raising local gasoline prices starting 2018 to make energy use more efficient.

The government seeks to commit about $9 billion to power generation and distribution each year, while it expects to privatize all electricity generation by 2020. This will require additional private investment to increase efficiency, meet environmental standards and replace ageing power units.

This development also provides opportunities for smart systems, alternative energy, energy efficiency systems and big data management.[5]

Prioritizing energy efficiency

One of the areas for major growth is energy efficiency. Energy costs make up to 10 percent of all average production costs. That figure spikes for energy – intensive industries as high as 40 percent. However, by implementing more innovative technologies, efficiencies can save as much as 30 percent.[6]

There is a rise in energy efficiency services companies (ESCOs) in the region, but it is still in the early stages. For instance, Saudi Arabia only has two licensed companies that provide these services.[7] The UAE has fewer than 30 ESCOs operating in the country, though only a handful were present in the 2000s. Dubai has 19 registered ESCOs while Abu Dhabi began a registering portal for potential companies to operate in the emirate beginning 2017.[8]

There is enormous potential for the Middle East's power sector, and plenty of room for a variety of new technologies and companies to help move into electricity's new era.

Sources:
1. http://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf
2. https://www.eia.gov/todayinenergy/detail.php?id=31232
Download CSV data: https://www.eia.gov/todayinenergy/detail.php?id=2250
3. https://data.worldbank.org/indicator/EG.ELC.PETR.ZS
4. Added oil/gas, then calculated from total production = 97% of total power generation https://www.iea.org/statistics/statisticssearch/report/?country=MIDDLEEAST&product=electricityandheat&year=2015
5. https://www.export.gov/article?id=Saudi-Arabia-Energy
6. https://www.siemens.com/global/en/home/company/topic-areas/energy-efficient-production.html
7. http://esco.seec.gov.sa/
8. https://www.rsbdubai.gov.ae/esco/list-of-accredited-escos/
https://www.thenational.ae/business/abu-dhabi-buildings-set-for-efficiency-retrofits-1.33288

Chapter 2

Power's New Direction

While natural gas remains the dominant source of energy, a diversified mix will be required to meet growing demand

Despite the region's push to use a basket of resources for power generation, gas-based power plants will maintain a 60 percent majority of installed capacity totaling 290 GW through 2035, according to research from IHS Markit. The London-based group also expects natural gas to double its contribution to 1,499 terawatt hours (TWh) annually in 2035 from 731 TWh in 2016.

The Middle East will need to construct 277 GW of new power plants in this time frame, while also considering a replacement for ageing infrastructure. In addition to new-build plants, there is a great deal of potential for brownfield plants. The region has 45 GW potential for efficiency improvements by upgrading facilities which are older than 30 years, and one answer could be found in combined cycle power plants (CCPPs).

CCPPs use a gas turbine and a steam turbine to produce electricity. The waste heat from the turbine is collected and repurposed to create more power via a steam turbine.

A simple cycle power plant without this extra waste heat component has an efficiency capacity ranging between 25 and 40 percent. With a CCPP, fuel efficiency can reach more than 60 percent.

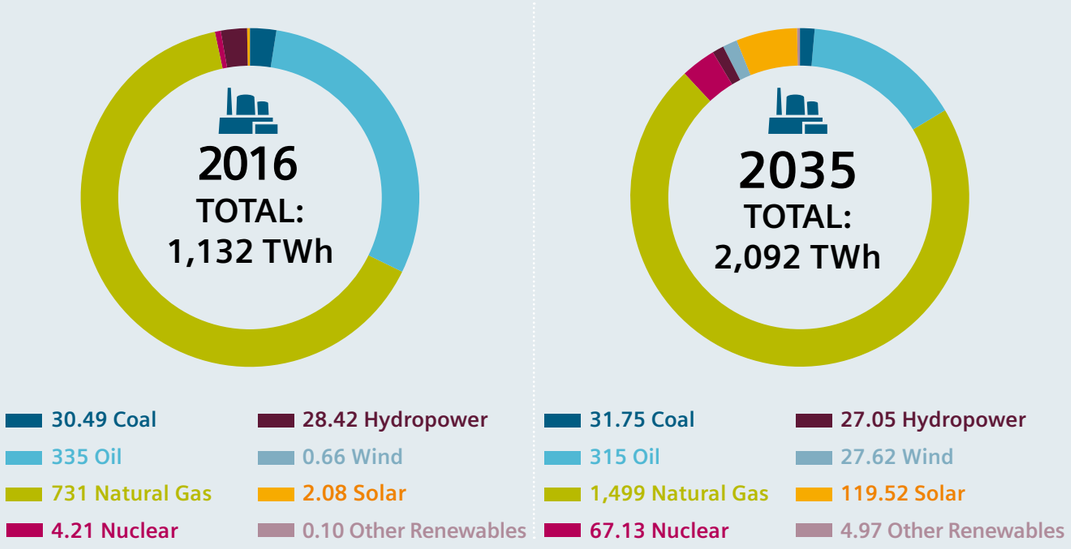
That movement has been underway in Egypt since 2015 as the country added new power plants with highly-efficient Siemens H-class gas turbines as part of a €6 billion mega-power project.

Three CCPPs, each with eight H-class gas turbines, will boost the North African country's power generation capacity by 45 percent. Each of the three plants is expected to become the largest of its kind in the world with a total combined capacity of 14.4 GW.[1] The efficiency of the power plants will translate into $1.3 billion in annual savings due to reduced fuel consumption, compared to installed power infrastructure.[2]

Highly efficient CCPPs are expected to dominate the market by 2030, as their share of thermal power generation reaches 65 percent.

Natural Gas No. 1 Source for Power Generation in the Middle East

Power generation demand by source 2016 – 2035 (TWh/a)



Source: IHS

Trends in Power Generation in the Middle East

277 Gigawatt (GW) of Additional Generation Capacity Required in Middle East by 2035

Significant increase in power generation 3.3% p.a. 2016 – 2035

Around 61 GW of capacity additions from solar power

Further potential for CCPP market from converting planned Steam Power Plants (SPP)

Highly efficient Combined Cycle Power Plant (CCPP) technology to comprise main capacity additions

High potential for wind power, not entirely reflected in moderate capacity additions, mainly in Saudi Arabia and Egypt

Fast adoption of new technologies: proven H-class gas turbine

Rise in Renewables

Another major change in the energy industry is the increasing popularity of solar and wind power, as a result of environmental targets and cost competitiveness.

- **Egypt: Supply 20% of generated electricity from renewable sources by 2022[3]**
- **Saudi Arabia: 9.5 GW of renewable energy added by 2023**
- **UAE: Clean energy to total 44% of power generation by 2050**

In some areas, the price for solar power has even reached cost parity with conventional fuels, which has helped heighten interest in the green energy sector. The Middle East has started to explore its potential. It is expected to add around 61 GW of new capacity from solar power by 2035, according to IHS.

The region is increasingly adding solar photovoltaic projects with more than 1 gigawatt of the technology expected to have been installed in 2017, according to Berlin-based cleantech advisory, Apricum. The best example of that growth comes from Dubai's Mohammed bin Rashid Al Maktoum solar park.[4]

The Abu Dhabi-based International Renewable Energy Agency (IRENA), an intergovernmental organization that helps countries with their energy transition, said that prices for solar PV technology dropped 58 percent from the five years to 2015. Saudi Arabia saw some of the world's lowest tariffs being submitted for its first commercial-scale solar project.

The cost competitiveness of wind has also grown in recent years. IRENA said that total wind turbine capacity in the region rose to 322MW in 2016 from 81MW in 2007. And there are prime opportunities for onshore wind found in Egypt and Saudi Arabia. In the five years to 2016, onshore wind power prices have dropped 34 percent to $47, and could go as low as $30 in the future.

The IRENA study in 2016 said that prices for solar PV modules and wind turbines had fallen by around 80 percent worldwide since 2009. However, given the intermittency of renewables – energy storage solutions will play an integral role in the region's renewable energy drive.

Providing cost-competitive storage solutions still remain an obstacle for green energy. Currently there are no reliable figures that shed light as to the storage requirements for countries in the Middle East.

Estimates for Germany, which has less year-round sunlight, indicate that this type of power generation from solar and wind sources will lead to storage facilities becoming indispensable in the Middle East. Analysis from Fraunhofer Institute on the German sector estimate that storage units in the country will need to have a capacity of up to 50 GW by 2030.

There are available technologies depending on the required storage capacity and duration. For conventional short-term, which provide capabilities for periods of minutes or hours, these include batteries, flywheel or compressed-air storage units. However, large scale facilities are seeing pumped storage power plants as an option, as well as hydrogen storage.

Plants such as this are currently under construction for the first time in the region with Dubai announcing in 2016 that it had started the work for a pumped storage power plant in Hatta. The plant will have a total capacity of 250MW, but these types of projects are still in a very nascent stage.

Power Generation Capacity by Source in the Middle East

Installed Capacity by Source (GW)

Source: IHS

Population pressures

One of the drivers for additional sources of power is a result of the growing population. The demand for electricity could increase by more than 70 percent compared to today's global demand of 21,375 terawatt hours (TWh), according to the International Energy Agency.[5]

The global population stands at 7.6 billion, but that figure is expected to jump 13 percent to 8.6 billion in 2030.[6] This translates to nearly 160 children born each minute.

In the Middle East, electricity demand grows 3.3 percent each year. Yet population is increasing at faster rates with places such as Kuwait, Oman, Qatar, Saudi Arabia and the UAE growing at 3.5 percent.[7] And even higher in other countries within the region such as Egypt, the most populous Arab nation, which adds nearly 2 million people annually.[8]

To make power supply sustainable, the Middle East will need to increase efficient power generation and retire older power plants with lower efficiency levels.

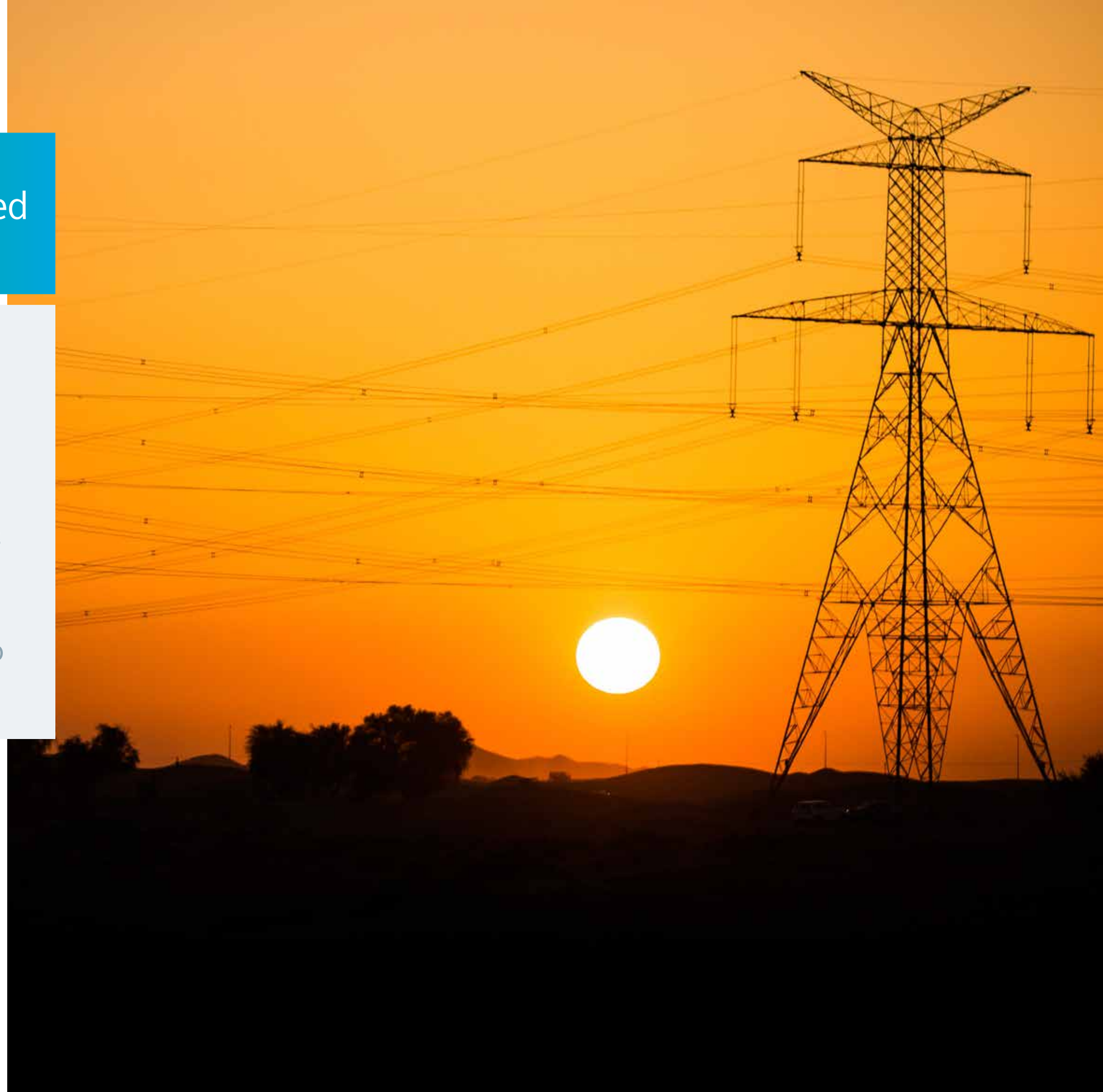
Countries are implementing various energy strategies to accomplish this, while considering decarbonization and digitalization.

Sources:
1. https://www.siemens.com/press/en/feature/2015/corporate/2015-06-egypt.php?content[]=Corp&content[]=WP&content[]=PG&content[]=SFS
2. https://www.siemens.com/press/pool/de/pressebilder/2017/power-gas/300dpi/ig2017030029pgen_300dpi.jpg
3. http://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/cm-stories/benban-solar-park-egypt
4. https://www.apricum-group.com/wp-content/uploads/2016/12/MENA-Solar-Outlook-2017.pdf
5. IEA World Energy Outlook 2017 report, page 234 (current policies scenario). Report is locked under a password from IEA, so I am unable to give a link
6. https://www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html
7. https://www.imf.org/external/pubs/ft/mena/04econ.htm http://www.worldbank.org/en/region/mena/publication/gep-mena-weak-investment-in-uncertain-times
8. CAPMAS

Chapter 3

Growth of Decentralized Energy Systems

Evolving demands are reshaping the energy landscape from large, centralized systems to single units that serve a specific function to the grid. Business models are being changed to meet this shift while new technologies are emerging to offer a smooth transition



Renewable energy, climate protection initiatives and interconnectivity are heralding a new style of energy system, challenging the norm of large power plants.

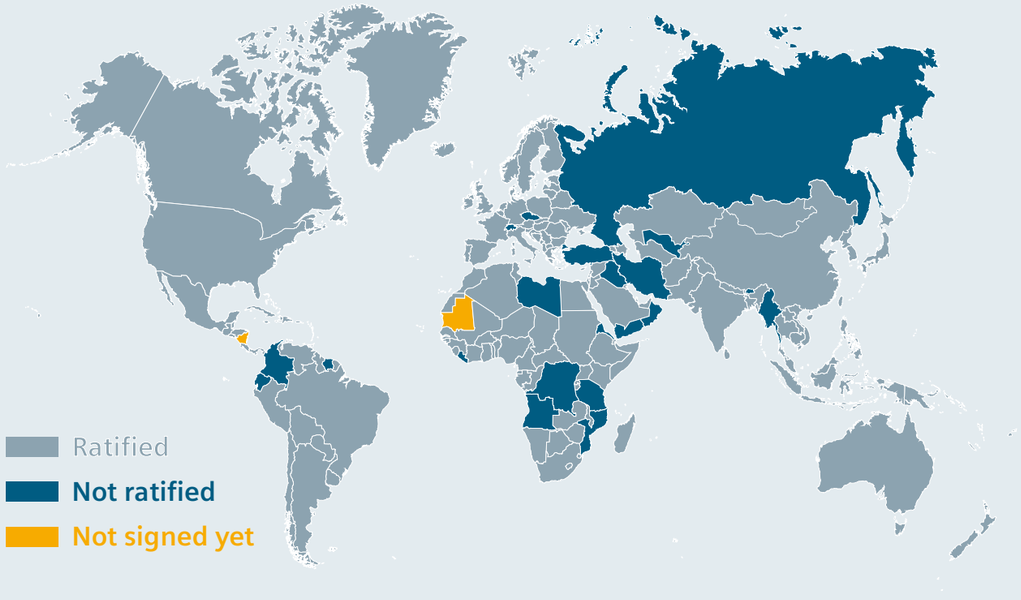
Decentralized energy systems (DES) produce power in the vicinity where it will be used, which helps reduce transmission losses while lowering carbon emissions. They are considered to be an economical and clean solution for the region. DES also help reduce dependency on utilities, enabling industrial players, for example, to produce their own power. Traditional power plants are built and even later expanded to handle peak loads or spikes in demand. As this only occurs at certain times, the power plant isn't always utilized to its full potential which is a waste of resource.

A study by the Massachusetts Institute of Technology (MIT) said that smarter consumption of electricity and the deployment of distributed energy resources, where cost-effective, could deliver billions of dollars in savings.[1]

Smaller systems providing power in the immediate vicinity can drastically cut carbon emissions which is in line with climate protection goals.

Sydney, Australia began implementing its first decentralized energy master plan in 2013, which broke up the area to determine heating, hot water and cooling demands. The aim was to significantly reduce electricity consumption and peak power by switching to thermal cooling. The master plan showed that 70 percent of Sydney's electricity demands and all the city's heating and cooling demands could be met, reducing greenhouse gas emissions by nearly 32 percent.[2] This is a perfect example that can be implemented in the region.

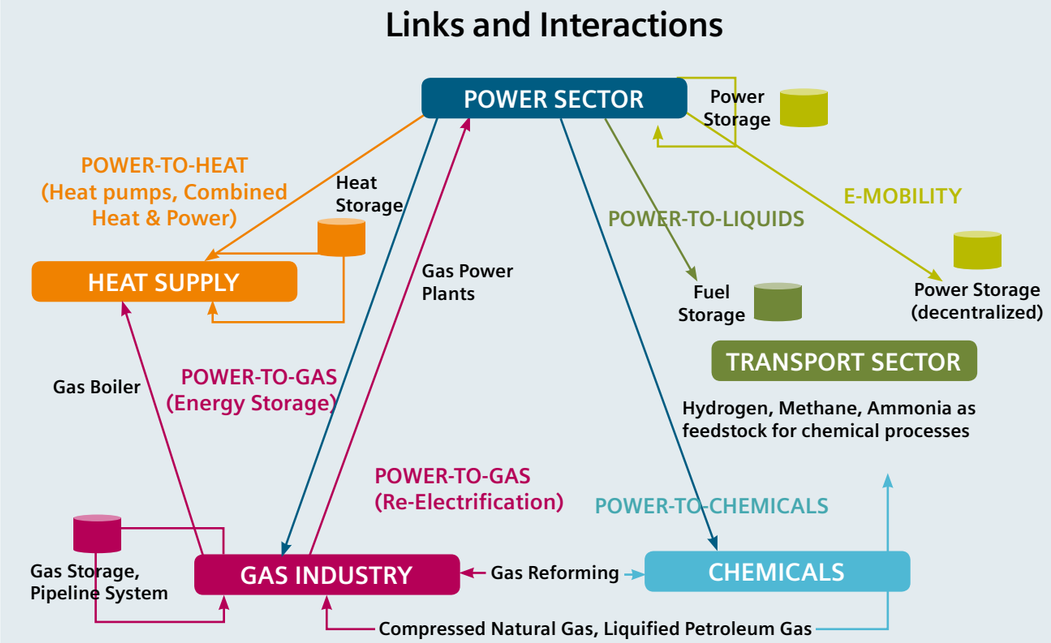
While All Middle East Countries Signed the Paris Agreement, not all Have yet Ratified it



Source: Lippert / Mayer, ifo SD 18/2017

Countries in the Middle East signed the Paris Agreement in 2015, which established a global action plan to limit climate change to well below 2 degrees Celsius while drastically cutting carbon emissions.

'Sector Coupling': Undisputed Lever for Entire Decarbonization of all End-user Sectors



Source: Siemens AG, based on FENES (OTH Regensburg)

Sector Coupling: the combination of three sectors that indispensably belong together: power, heat and mobility.

There are businesses and customers that are ready to take control to generate their own electricity. This has resulted in utilities searching for ways to manage slowing demand growth as well as handling and integrating a growing influx of electricity from distributed sources.

American firm, First Solar, and Saudi Arabia's Al Watania Agriculture began piloting a project in 2016 using a small-scale solar power system for irrigation in the Al Jouf region. The project produced 1,476 megawatt hours (MWh) of electricity per year, reducing carbon emissions by 1,100 tons annually or the equivalent of planting just under 30,000 trees.[3]

While renewables have become mainstream, the International Energy Agency (IEA) said that tackling carbon emissions requires more attention be given to the heat and transport sectors. This includes electric vehicles, thermal storage in district heating, heat pumps and demand response.

Most importantly, to reach these ambitious

DECENTRALIZED ENERGY SYSTEMS

DES are smaller entities that have a single purpose for the grid

- **Distributed energy for renewable sources**
- **Distributed storage**
- **Energy efficiency**
- **Demand response**

targets, various parts of the energy system must be linked. Many renewables can only succeed if there are effective options for system flexibility in the way of digitalization and smart technologies.

New business models for utilities

Germany's largest utility, E.ON, took the decision to restructure its business in 2014, selling off conventional assets to focus more on distributed energy. This resulted in two separate companies, one focusing on conventional power generation while the other was geared to "renewables, energy networks and customer solutions".[4]

For the short-term, the Middle East must optimize the supply chain and increase energy efficiency by sector coupling or by combining the power, heat and mobility sectors. This will require an investment in highly efficient power generation technologies and burning different types of fuel.

Included in this is Siemens' 44 MW gas turbine for mobile power generation, which addresses the needs of fast power for growing markets. The system can be installed in two weeks with a higher amount of electrical output compared to models on the market currently.

The innovation can ramp up to full power in less than 9 minutes from the start without the need for an auxiliary system to maintain the unit in an operationally ready standby mode. If there is a power shutdown, the unit can be restarted at any time to restore power quickly and has no "hot lockout" restrictions.[5]

Hydrogen a ripe solution for energy storage

When thinking of sector coupling, most would instantly jump to thermal storage or batteries – particularly lithium ion which is being deployed in electric vehicles such as Tesla.

Yet electrolysis is an ideal solution for areas that have plenty of sunlight year-round with a significant surplus energy capacity. Hydrogen can be used to store electrical energy from a range of just a few kilowatts to gigawatts, for several weeks.

The chemical element can be used as a process gas in industry or as a fuel for emission-free fuel cells in mobility. The UAE is already testing the hydrogen-powered Toyota Mirai and opened its first hydrogen fuel station in 2017.

Hydrogen can also be further refined to create valuable raw materials such as ammonia for fertilizer production or methanol as a base chemical and fuel. With low-priced electricity in the region, it is worth storing the hydrogen and converting back into power through combined cycle power plants, guaranteeing security of supply.

Siemens is developing the Silyzer electrolyzer to balance the electricity that is generated on a fluctuating basis, and has already placed these systems in operation in Europe. This technology is ideally suited for wind and solar power, which is generated on an irregular basis.

The greater amount of convertible electricity also means a larger amount of capacity for power systems. The solar parks in the Middle East, which are considerably larger than those in Europe, could provide the basis for electrolyzers of completely new dimensions.

Technological additions such as this could offer a fundamental transformation of the region's power sector. The stability of the grid and the reliability of the supply would be more secure than ever before. And it would be no longer inconceivable that countries such as Saudi Arabia and Kuwait could be more associated with wind and solar power than with oil.

The Siemens 44 MW gas turbine for mobile power generation can bring fast power supply to growing economies.

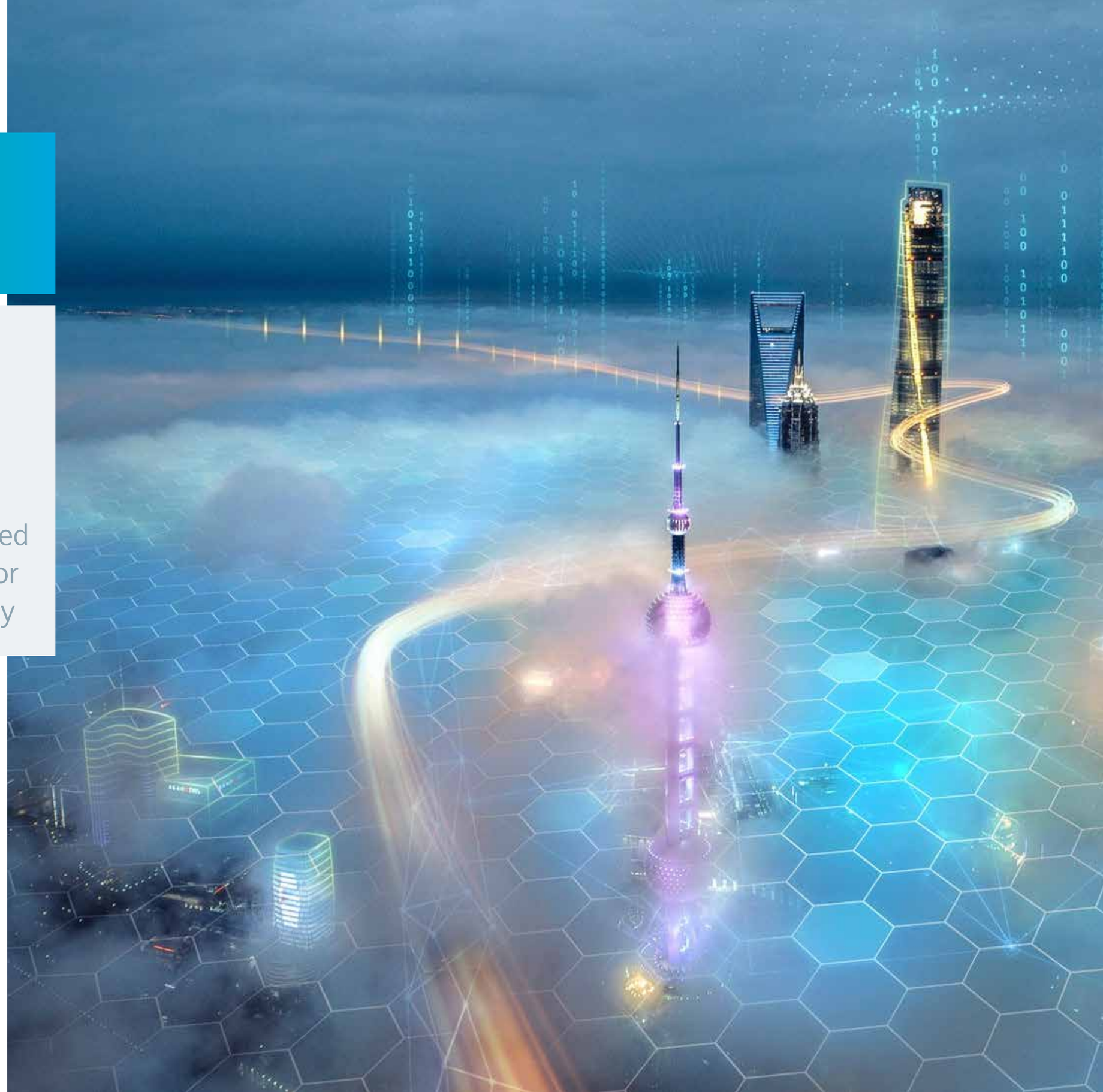
Hydrogen fuel cell in a laboratory

Sources:
1. https://energy.mit.edu/wp-content/uploads/2016/12/Utility-of-the-Future-Full-Report.pdf
2. https://www.ieac.info/City-Of-Sydney-Decentralized-Energy-Master-Plan-Case-Study
3. http://investor.firstsolar.com/news-releases/news-release-details/first-solar-al-watania-agricultural-co-pilot-solar-powered
4. https://www.eon.com/en/about-us/media/press-release/2016/separation-of-eon-business-operations-completed-on-january-1-uniper-launched-on-schedule.html
5. https://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2017/power-gas/pr2017030234pgen.htm

Chapter 4

IoT Highways and Roadblocks

Digitalization is helping improve efficiencies of power plants while also reducing costs; however, with data and analytics increasingly exchanged through cloud-based technologies, the energy sector must increase its cyber security



The Internet of Things (IoT) is dominating our lives, including the way we source electricity. Maximizing the output of various energy systems requires better and easier communications to pull necessary analytics.

The digitalization of power systems allows for more monitoring and control capabilities. With more data, information can help better target consumer needs, prevent shutdowns and quickly respond to a malfunction to mitigate the impact.

In fact, the utility of the future will be a fully-integrated online suite. The IoT will improve operations and increase flexibility throughout the value chain which increases efficiency and profitability. McKinsey & Company places conservative estimates that digital optimization can boost profitability by 20 to 30 percent.[1]

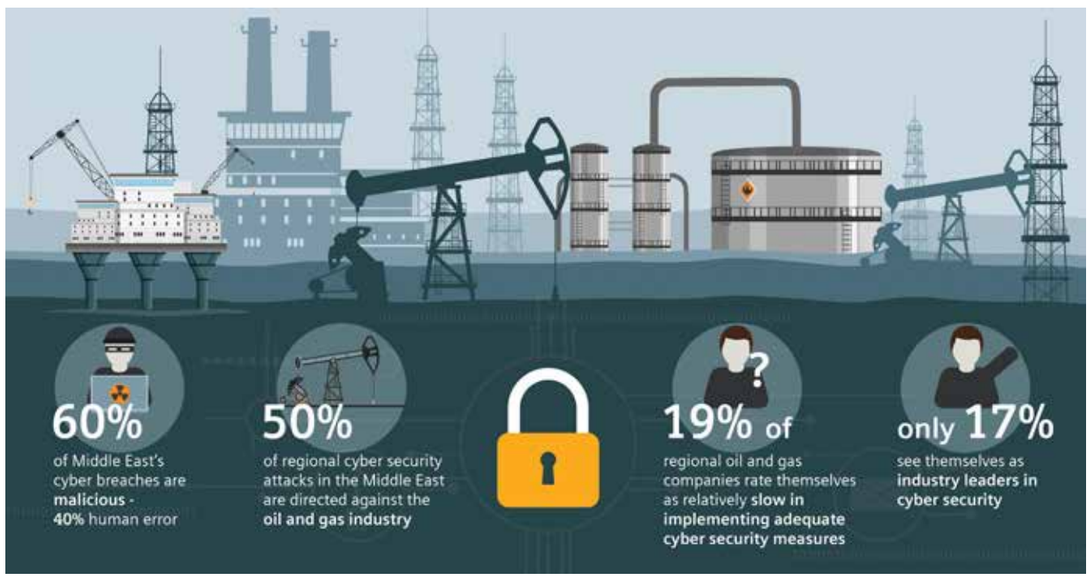
Smart grid systems, for instance, enable the network to function like the internet. By using computers, automation and new technologies, the grid can respond in a quicker timeframe - saving costs and responding quickly to potential problems. By utilizing the full potential of smart meters, electrical utility companies could remotely switch on and off certain consumers, balancing supply and demand in their grid.

A greater access to data creates transparency and allows better decisions. For instance, a gas turbine can generate – on average – 30 gigabytes of operating data each day. By evaluating this information, a user can determine when the turbines need to be serviced so customers experience less downtime.[2]

With Siemens Remote Diagnostics Services, data is collected throughout the day and compiled into an intelligent analysis with around the clock virtual assistance for any type of technical issue. This also allows customers with multiple sites to have the data aggregated in one location. It can also help with load forecasting, which is required by utilities to ensure grid stability.

For the Middle East, major efforts have been underway for the past couple of years to optimize operations to help decrease costs. The region has historically subsidized electricity, but sustained low oil prices have hit government earnings. This led to many in the Gulf Cooperation Council (GCC) to start to slash subsidies to shore up new streams of revenue.

One of the methods seen in the region is demand side response (DSR), using the information highway to bring about a change in consumer behavior through various methods.



Providing digital applications for an all-electric world

Grid applications

- Digital twin and grid simulation
- Grid Control
- Substation device management
- Outage management
- Advanced device management
- Power quality analysis
- Asset performance management

Grid edge and vertical applications

- Distributed energy resource management
- Meter data management/Meter-to-Cash
- Meter data analytics
- Revenue protection
- Market transaction management
- Virtual power plant/demand response
- Connected e-mobility
- Energy efficiency
- Critical power management
- Distributed energy resources performance monitoring

EnergyIP powered by MindSphere

Previously, the design of power systems and early metrics focused on periods of maximum customer demand. Technological advancements have provided the tools that allow for more variable generation and reliability, but the evolution of the industry is a continuing process.

Abu Dhabi, for instance, charges some customers more for power during the hot summer months from June 1 to September 30.[3] Lowering peak demand can reduce cost for the industry and generation capacity.

Another tool that can be used by management is software for metered consumption data. This can be applied to support billing, load profiling, forecasting and asset loading.

The rising cyber threat

But as the digital age continues to grow and encompass more of our lives, so too do the threats.

Siemens and the Ponemon Institute conducted a survey of Middle East oil and gas executives in 2017, that revealed cyber risk is becoming a larger threat to operational technology than informational technology.

Many of the cyber attacks in the region are extremely sophisticated. Nineteen percent of the respondents felt their companies were slow at implementing efficient cyber security measures. Half of all cyber attacks in the region are directed against the hydrocarbon industry, which can harm operations and safety.

As a result, an emerging trend of cyber attacks is designed to disrupt physical devices or processes used in operations. In a digital environment, industrial cyber is the new risk frontier.

Protecting these systems is an increasing worry, particularly with critical infrastructure in the power sector. In 2014, a German steel mill was attacked by hackers who used emails to release malware that penetrated the mill's automation system causing severe damage.

And three years on, a growing amount of cyber threats have resulted in terms such as "WannaCry" becoming a household name. Cyber security firm Symantec said that governments around the globe have been forced to deal with "massive distributed denial of service attacks launched from unsecure IoT devices and to defend against a notable increase in the capability of cyber

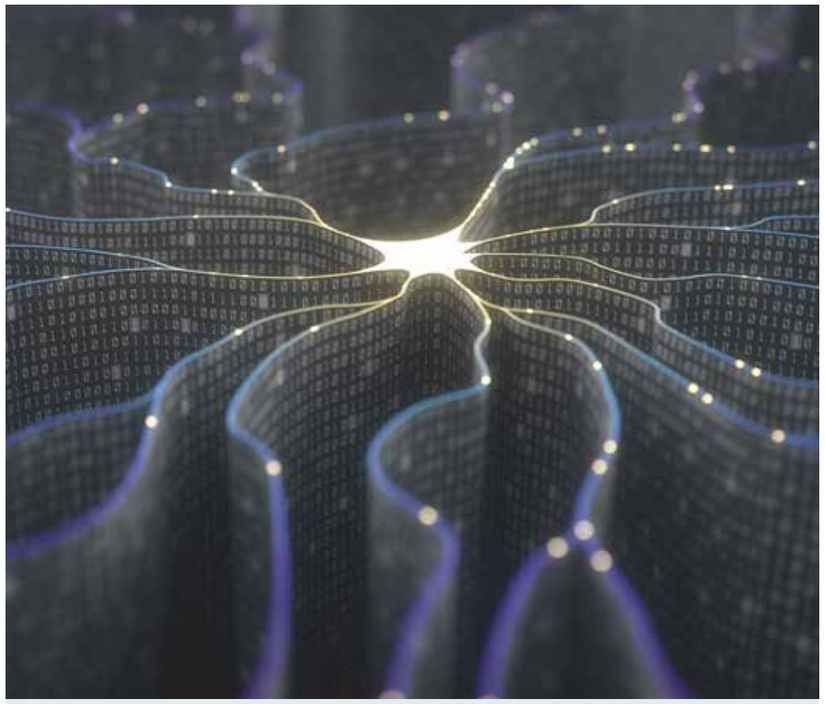
criminals to operate without malware".

More than 7 percent of power utilities worldwide were attacked in 2016, totalling 75 attacks.[4] The WannaCry malware made less than $100,000, but infected more than 200,000 units.

Symantec said that cyber crimes generate at least $5 million per year.[5] A hacker can break into an IoT device in two minutes, but securing a power system is far different than protecting a corporation. The speed of digitalization combined with an unequal level of cyber security investment can make a power system vulnerable.

More than a decade ago in 2003, the Northeast Blackout in the United States left 50 million people without power for four days and resulted in up to $10 billion in economic losses.[6] Without electricity, this could increase even more resulting in death tolls as health and safety systems fail.

Governments and utilities are increasing spending to shore up protection on their systems, but a 2015 survey by PriceWaterhouseCoopers (PwC) said that the investment in cyber security still lagged. For power and utilities, information security spending in 2014 increased by 9 percent,



Digitalization of the Energy System / IoT Trends

Driver and trends shaping the digitalization of the Energy system

- Cost down and high growth of (distributed) renewable technologies (PV)
- Decreasing cost of sensors, chips, (wireless) communication
- Increasing role of smart devices
- Decreasing costs for batteries and rise of distributed storage applications
- Electrification of transport, heating, industrial sectors
- Further automatization & digitalization of energy intensive industries
- Autonomous systems & robotics in particular self driving (electric) vehicles

Benefits of Increasing Digitalization of the Energy System

Grid flexibility & management in smart grids

- Managing distributed assets and providing services are key areas where Industrial Internet of Things SW and platforms can facilitate operations
- Virtual Power Plants / Demand response / load aggregation: demand profiles are becoming peakier lowering demand peak can reduce cost for industry and reduce needed generation capacity; Demand Response Management Systems (DRMS) help managing utility demand-response (DR) programs
- Load forecasting is the key functionality required by utilities to ensure grid stability, reduce outages, reduce idle capacity
- Transmission outage management systems coordinate planned outages in the generation and transmission grid
- Advanced distribution management system (ADMS): a software suite supplying requirements for electric distribution network management and optimization

Energy efficiency

- Meter data management: software products used for the management of metered consumption data which can be used to support billing, load profiling, forecasting and asset loading

Operation & maintenance of power sector assets

- Asset Performance Management reduces costs and operational risks through longer life of assets, lower operating and support costs and less equipment damage
- Drones for autonomous inspections, such as the maintenance of solar and wind power generation equipment or power distribution lines
- Augmented and virtual reality enables field workers to discover more quickly the specific location of assets in the vicinity and to view associated information e.g. current operating or thermal conditions

compared to 25 percent a year earlier, according to respondents. Even more is that the amount allocated to cyber security out of the total IT budget has stalled at 4 percent for the previous five years.

Security must be considered at every stage from the beginning of development of digitalized energy systems and power plants and monitored throughout the life-cycle. Digital enterprise suites can provide a multi-layer concept based on plant and network security as well as system integrity.

Digitalization, including protecting against cyber threats, will create new job opportunities. The UAE is hoping to help drive the momentum in the Middle East with its "One Million Arab Coders" initiative, which will train young regional talent in the "language of the future".

Overall, digital initiatives provide a great deal of opportunity for the power sector with World Economic Forum estimates that from 2016 to 2025, the industry can capture an additional $1.3 trillion of value.[7]

Sources:
1. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/the-digital-utility-new-opportunities-and-challenges
2. https://www.siemens.com/global/en/home/company/topic-areas/digitalization/digital-services.html
3. https://www.addc.ae/en-US/residential/Documents/02-English.pdf
4. https://www.symantec.com/content/dam/symantec/docs/reports/gistr22-government-report.pdf
5. http://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/ransomware-a-growing-menace.pdf
6. https://www.cfr.org/report/cyberattack-us-power-grid
7. http://reports.weforum.org/digital-transformation/electricity-generating-value-through-digital-transformation/

Chapter 5

Dynamics Shaping the Future

Many regional governments have established clean energy targets, which is transforming the outlook of the power sector in the Middle East, particularly in the UAE and Saudi Arabia

UAE

The UAE is in a period of transition with a very ambitious diversification strategy underway, while the country continues to face a rise in water demand.

Natural gas makes up more than 90 percent of the country's power mix, but the UAE released its first nationwide energy diversification strategy in 2017 though individual emirates had existing plans.

The UAE Energy Plan 2050 targets carbon emission cuts of 70 percent, clean energy use accounting for 50 percent of power generation and improving energy efficiency to the tune of 40 percent. This initiative is set to save the country Dh700 billion (US$191bn) by the half century.

This policy mandates that 44 percent of the country's energy will come from renewable energy, and 38 percent from gas. In addition, 12 percent of the mix will be made up from clean fossil such as the Hassyan clean coal power plant and 6 percent from nuclear energy.

Spending in the utility sector, including power generation and transmission and distribution, will have a compound annual growth rate (CAGR) of 5.9 percent from 2016 to 2022, according to data from IHS Markit.

The UAE plans to invest $50 billion by 2022 in its energy sector, according to the Arab Petroleum Investments Corporation (Apicorp).[1] Around 35 percent of planned investments, or $18bn, is at the engineering, procurement and construction phase.[1]

The Federal Electricity and Water Authority (FEWA), the utility responsible for power in the Northern Emirates, is developing large power plants to supply reliable electricity to the populations there. Abu Dhabi Water and Electricity Authority (ADWEA) and Dubai Electricity and Water Authority (DEWA) are exploring optimization options for their current power plants. DEWA is also building the Mohammed Bin Rashid Al Maktoum Solar Park, the largest single-site solar park in the world based on the Independent Power Plant (IPP) model.

Masdar and its parent company Mubadala have also played a pioneering role in creating environmentally-friendly ecosystems around the world, introducing new business models and pushing the boundaries to build clean and sustainable cities.

In the past couple of years, solar photovoltaic (PV) tariffs have been lower than the cost to generate electricity from natural gas.

The UAE plans to invest $50 billion by 2022 in its energy sector, according to the Arab Petroleum Investments Corporation.

By implementing new sources of energy into the power mix, the country could have the potential to become a net electricity exporter. And these greenfield projects are being awarded under an independent power producer (IPP) model.

In the past couple of years, solar photovoltaic (PV) tariffs have been lower than the cost to generate electricity from natural gas. This will lead to some power plants being replaced by renewables, mainly solar.

At the same time, major energy users are faced with the country slashing subsidies on energy and water while also liberalizing gasoline and diesel. The UAE is looking to cut costs and narrow fiscal deficits, but the price increase also puts pressure on customers to shore up efficiencies to maintain healthy margins. This caused companies, such as Abu Dhabi's Arkan Building Materials, to reassess its energy expenditures once the price for natural gas increased. The company's most lucrative asset is the industrial sector's most energy intensive product, cement.

Making cement requires energy amounting to about 10 times its share of the gross output of goods and services.[2] To maintain a healthy profit, Arkan decided to implement a new waste heat recovery technology which will help offset the electricity price hikes while cutting carbon emissions.

This will also present an opportunity for more decentralized power generation for industries, including the hydrocarbon sector. As the industrial sector does not consider power generation as its core business, companies will replace the traditional engineering, procurement and construction (EPC) method and may opt for an IPP model.

Additional power capacity will also be needed to meet the growing demand for potable water. Around 65 percent of all the water used in the UAE is supplied from groundwater while the remainder is provided via recycling as well as desalination, which is an energy-intensive process to remove brine from seawater.[2]

As population increases and groundwater reserves diminish, meeting the growing demand for water – and the energy required to produce it – will need to be addressed.

Saudi Arabia

Saudi Arabia's energy transition is opening the door to various opportunities as the kingdom looks to export energy and technology. Overall, the kingdom needs to increase its power generation to meet future demand.

Saudi's National Transformation Plan which includes a $50 billion spending program, sets an initial target for the installation of 9.5 GW of renewable energy by 2020. It also seeks to transform the kingdom into a regional hub for manufacturing.

Saudi Arabia has always been a playground for large power plants. However, there has been a lack of any new developments over the past two years.

Now, the kingdom is looking to expand, and much like the UAE, the country has decreased subsidies on electricity. Yet as the largest economy in the region, there are several different paths that are available. Saudi Arabia is planning to invest $124 billion in the energy sector, but there's industry excitement around its renewable energy program.

NEOM, the Red Sea economic mega city, will turn to renewables while 700 megawatts of solar and wind projects are currently being tendered, even having some of the world's lowest tariffs being submitted for its first commercial-scale solar project. Another element is to displace diesel by encouraging growth of local companies as well as opening the door to smaller players by making available renewable power projects ranging between 50MW to 100MW.[3]

In two decades, a gas turbine that runs on crude oil could cost the same for maintenance as the original turbine.

The Kingdom would benefit from highly-efficient gas turbines that can help it save crude oil for export.

The key is to ween the country off its heavy use of crude oil in its power generation sector. The resource is cheap, but the operational cost is extremely expensive. The three-year lull in low oil prices has resulted in the kingdom looking for other ways to shore up its revenues. As the country will need financing to meet its diversification goals, these crude oil plants will be phased out. In two decades, a gas turbine that runs on crude oil could cost the same for maintenance as the original turbine.

The 180 targets set out in the transformation plan will help increase the country's non-oil revenue to SAR1 trillion. Another priority is to localize and export expertise across numerous sectors, with Saudi Aramco leading with its own In-Kingdom Total Value Add (IKTVA).

The program aims to have 70 percent local content across sectors creating 500,000 jobs. The energy giant also expects to export 30 percent of the country's energy sector products by 2021.

Another diversification route could be to rollout decentralized energy systems – among the GCC member states, Saudi Arabia has the biggest potential for this. But while it is trying to diversify in various industries, it is not a very industrialized country presently.

The region's power sector is fast growing with numerous gateways for a variety of industries. Challenges in the Middle East remain affordability, sustainability, efficiency and energy security and therefore diversification and new technologies in the power sector will become increasingly prevalent.

Sources:
1. http://www.apicorp-arabia.com/Research/EnergyReseach/2017/APICORP-Energy-Research_V02_N05_special_report-2017-.pdf
2: Environmental Agency of Abu Dhabi: https://www.ead.ae/Documents/Corporate%20strategy%20-%20Eng.pdf
3. https://www.thenational.ae/business/energy/saudi-arabia-to-also-welcome-small-renewable-energy-firms-1.609594

Siemens LLC Building B-05

Masdar City

+971 2 616 5100

Siemens is a global technology powerhouse that has stood for engineering excellence, innovation, quality, reliability and internationality for 170 years. The company is active around the globe, focusing on the areas of electrification, automation and digitalization. One of the world's largest producers of energy-efficient, resource-saving technologies, Siemens is a leading supplier of efficient power generation and power transmission solutions and a pioneer in infrastructure solutions as well as automation, drive and software solutions for industry. The company is also a leading provider of medical imaging equipment – such as computed tomography and magnetic resonance imaging systems – and a leader in laboratory diagnostics as well as clinical IT. In fiscal 2017, which ended on September 30, 2017, Siemens generated revenue of €83.0 billion and net income of €6.2 billion. At the end of September 2017, the company had around 377,000 employees worldwide.